DEPARTMENT OF COMMERCE AND LABOR
BUREAU OF FISHERIES
GEORGE M. BOWERS, Commissioner

OYSTER CULTURE EXPERIMENTS AND INVESTIGATIONS IN LOUISIANA

Bureau of Fisheries Document No. 731

WASHINGTON
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By H. F. MOORE and T. E. B. POPE,

Assistants, United States Bureau of Fisheries.

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CONTENTS.

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By H. F. Moore and T. E. B. Pope.

PREVIOUS INVESTIGATIONS, RESULTING LEGISLATION AND ITS EFFECTS.

In the winter of 1898 and 1899 the Bureau of Fisheries made a reconnaissance of the oyster beds on the Louisiana coast between Mississippi Sound and Atchafalaya River. The report[a] on this work contained a chart giving with approximate accuracy the location of the oyster beds of a considerable part of St. Bernard Parish and a general description of the beds, not only of that region but of practically the entire oyster-producing area of Louisiana. The coast west of the Atchafalaya was not included, partly for lack of time, but principally because the conditions there appeared to be such as to militate against the development of any considerable oyster industry.

Data were published relating to the salinity of the water, the food, spawning, growth, and enemies of the oyster, the general character of the bottoms, the relative prevalence of freshets and crevasses, and, in general, all factors having a bearing upon oysters and oyster culture.

Some attention was given to the extent of the oyster-planting industry, the methods employed, and the results obtained, but no experiments were made to determine in a definite way the results which could be expected from a systematic endeavor to establish oyster culture on a rational basis and to substitute for the haphazard practices on the natural beds the more reliable methods certain to be followed on planted grounds under private supervision and ownership. Based on the observations, the report included a number of recommendations in regard to the requirements for the conservation, protection, and development of the oyster industry both as to the

[a] Report on the oyster beds of Louisiana, H. F. Moore, Report United States Fish Commission, 1898, p. 45–100.

administration of the public beds and the establishment of private ones.

After several years of agitation and discussion the legislature in 1902 passed a general oyster law based on the recommendations of that report. The law was materially amended in 1904 and 1906, and as it now stands on the statute books it embraces practically in their entirety those recommendations and suggestions.

The effects of the law were almost immediately apparent in the growth of the oyster industry and the increase which it contributed to the state revenues. Prior to its passage jurisdiction over the oyster bottoms was lodged solely in the police juries of the several coastal parishes, with the result that the administration of the laws was contradictory and ineffective. The potential wealth lying concealed beneath the tide waters of the state was not appreciated and the oyster industry was neither protected nor fostered.

The several local bodies having jurisdiction had neither the inclination nor the machinery for an effective administration of the interests committed to their charge. The oyster beds practically all lie in waters remote from the habitations of man, and to police them effectively is a matter of considerable physical difficulty, requiring the use of boats to cruise along the coast constantly. Moreover, the police juries and their executive agents were usually men having but slight coastal connections and interests, and it is not surprising that they were more concerned in parish matters more immediately under their notice and within their experience and understanding.

The fundamental feature of the new law was the creation of a state oyster commission having sole jurisdiction, in oyster and cognate matters, over the entire coast, insuring consistency and uniformity of administration, and endowed with ample police powers to make effective the law and the regulations which it authorizes. The larger resources of the state permit the employment of boats capable of policing the beds during the bad weather of the oyster season, requiring the oystermen to observe the cull laws and other essential regulations which under the older régime were disregarded with impunity.

The next most important feature of the new legislation was the passage of consistent and reasonable provisions for the encouragement and regulation of oyster culture. For those who comply with reasonable requirements this provides, in lieu of the former uncertainty, an assured tenure of sufficient duraton to prove attractive to prospective oyster culturists, and while the restriction upon the acreage (1,000 acres) that may be allotted to any one person is such as to prevent the establishment of a monopoly of the best grounds, it does not prevent the acquisition of an area sufficient to satisfy the

legitimate requirements of a considerable corporation. The rental is $1 per acre for the first fifteen years of the term of the lease and $2 per acre for the succeeding ten years, and in addition there is a tax of 3 cents per barrel (3¼ bushels) on all oysters marketed, whether from the natural reefs or planted beds.[a]

Partly on account of the unusually favorable natural conditions under which the oyster industry is conducted in Louisiana, but largely by reason of the protection which the laws accord to the natural beds and the encouragement which they extend to oyster culture, the oyster fishery of the state has made extraordinary progress since the establishment of the commission. This is illustrated in the following table:

PRODUCTION OF OYSTERS IN LOUISIANA IN RECENT YEARS.

Year.	Product.	Increase per annum.	Year.	Product.	Increase per annum.
	Bushels.	*Per cent.*		*Bushels.*	*Per cent.*
1897	959,190		1905	2,187,000	35
1902	1,198,413	5	1906	2,486,256	14
1903	1,534,000	28	1907	3,035,370	22
1904	1,620,576	6	1908	[a] 3,600,000	[a] 19

[a] About.

In the five years preceding the enactment of the first oyster law the increase in the production, which was mainly from the natural beds, was 20 per cent, while in the first five years following the passage of the act, and after it had been improved and amended, the increase was 154 per cent.

The data for 1897 and 1902 are based upon the canvasses of the Bureau of Fisheries, while those for subsequent years are the quantities upon which were paid the "privilege tax," of which more will be said hereafter.

The increase between 1902 and 1903 can not be definitely accounted for and may possibly be due to a difference in the method of gathering the statistics, but from 1904 onward the increases are in part due to the fostering of new oyster houses and the care of the natural beds, but particularly to the fact that the private oyster bottoms were coming into productiveness. The natural beds of the state still produce in quantity more than the planted beds, but the disparity is yearly becoming less, and in 1908 the value of oysters marketed from planted grounds slightly exceeded that of those derived from the natural beds. The quantity produced exceeded the whole product of the state at the time of the investigation of 1898,

[a] The laws in full may be had by application to the Louisiana Oyster Commission, Maison Blanche Building, New Orleans, La.

and almost equaled the yield from all sources in 1902, when the first comprehensive oyster law was enacted.

The increase in the area of bottoms under leasehold since the enactment of the present laws has been astonishing. The exact area of the leased bottoms of the state at the time of the investigation of 1898 can not be stated, but in Terrebonne Parish there were then on record 32 leases, aggregating about 160 acres. Ten years later, March, 1908, after the new laws had been in force but six years, there were operative in that parish 411 leases, aggregating 5,803 acres. In 1898 the state derived from its oyster lands in Terrebonne Parish not over $80, and the parish not exceeding an equal amount. In 1908 the gross income of the state from the same waters was about $8,900.

From 1885 to 1902, under the parish administration of the oyster fishery, but 521 leases, covering 2,820 acres, had been executed in the entire state and many of them had lapsed at the latter date. In March, 1908, there were in the state 1,692 effective leases, covering 22,135 acres of bottom.

It is interesting to observe that although the state permits one person or corporation to lease a maximum of 1,000 acres, the average leasehold at the present time is but 13 acres. There is apparently no tendency to "acquire a monopoly," which is so much feared by opponents of oyster culture, and while several leases of from 500 to 1,000 acres have been granted, most of the holdings are in 10-acre parcels leased mainly by persons formerly working on the natural beds.

There is no doubt that the average size of the leased beds will increase. The oyster-planting industry of the state is as yet, in large measure, in the more primitive stage. Seed oysters from the natural beds are laid down for a year or less and a small acreage suffices for a considerable product. The inevitable necessity of changing this method to that of planting cultch is beginning to make itself felt, and as under the latter system the oysters will probably be left at least two years on the bottom the requirement of larger holdings will assert itself.

If the oyster industry of the state is to continue to expand in the future as in the past, the sooner this change in methods of culture is established the better for all concerned. Carrying the oysters from crowded natural reefs and bedding them for a few months on private grounds where the conditions are better produces a superior oyster and undoubtedly saves many that would die in the struggle for existence under natural conditions. In that way, properly conducted, transplanting increases both the volume and the value of the oyster product, but the area of the natural beds is fixed as to its maximum, and their ultimate productive capacity is correspondingly

fixed. They can, as a whole, produce but a more or less definite maximum quantity of oysters, and experience in other places has shown that this maximum is soon reached in the development of the fishery, and that thereafter the productiveness of the beds decreases by reason of the intensive fishery which the demands of the markets induce. The natural beds inevitably tend to depletion despite all efforts at their protection.

It can not be definitely stated that the maximum productiveness of the natural beds of Louisiana has yet been attained, but there is reason to believe that this is the fact in some localities. In Terrebonne Parish, according to observations made incidentally during the term of the present experiments, but more especially as shown by the studies made by Mr. L. R. Cary[a] in 1906 and 1907, certain reefs highly productive in 1898 are now depleted or barren, mainly as a result of overfishing.

Whereas at the time of the investigation of 1898 practically all oysters from this parish came directly from the natural reefs, it is stated that the greater part of the product now comes from the planted beds. Most of this product, however, has its prime source in the natural beds, whose oysters are transplanted or bedded for a year or less on the private grounds. By this method of planting the drain on the natural beds is maintained or even accelerated under the present system of granting permits to take unculled oysters for planting purposes.

PERMITS TO TAKE UNCULLED OYSTERS.

Under the laws now in force the oyster commission is empowered to issue special permits to take rough or unculled stock from the public beds for planting purposes, provided the leased bottoms to which they are removed are over 6 miles distant from known natural reefs. This provision was incorporated in the law for the purpose of encouraging the establishment of seed beds on bottoms presumably too far removed from spawning oysters to allow them to receive a natural set of spat on planted cultch, the issuance of the permits being optional with the oyster commission.

It is a common practice for those to whom such permits are issued to take up not only large and small oysters, but quantities of shells also, or, in other words, to remove, bodily, portions of the reefs themselves. The reefs are thus depleted not only of their oysters, but of the bottom to which they are attached, and recuperation is prevented by the loss of the shells which under normal natural conditions furnish the only places for the attachment of fresh generations of young. There is thus reduction in both actual and potential productive-

[a] A preliminary study of the conditions for oyster culture in the waters of Terrebonne Parish, La. Bulletin 9, Gulf Biologic Station, Cameron, La.

ness, and the ultimate result of the policy which permits it is not difficult to see. It must inevitably be the accelerated depletion of the natural beds.

The purpose of the provision is meritorious, but it rarely should be necessary to put it into effect under the conditions obtaining in Louisiana. Outside of Barataria Bay there were very few places suitable for oyster culture which were at the time of the enactment actually more than 6 miles removed from spawning oysters, either natural or planted; and even in that region the planting of brood oysters is no longer necessary, since the establishment of this Bureau's experimental plants and the commercial oyster culture which they have encouraged furnishes an ample supply of spawning oysters.

The authors have received the impression that these permits have been issued rather too generously for the best welfare of the natural beds, for not only have they been granted to practically all applicants, but it is understood that they have been issued to the same persons in consecutive years. Even in cases in which it is necessary or advantageous to grant to a planter permission to take unculled material from the natural beds, the practical end contemplated by the law is served by one permit, which will allow the establishment of a self-perpetuating colony of brood oysters, sufficient for all time, unless destroyed by crevasses, the inroads of enemies, or other accidents. If the oysters do not thrive under the general environment to which they are transplanted, that in itself is evidence that the locality is for some reason ill chosen and additional experiment in the same place is likely to prove futile. If the bottom is to be used merely as a bedding or fattening ground, to be planted with oysters year after year, the issuance of the permits is unnecessary.

The present practice not only injures the natural beds, but it tends to discourage the planting of shells and other cultch, without which the oyster industry of Louisiana can never reach its full productive development. For both reasons it appears advisable that the issuance of these licenses or permits should be restricted and their necessity subjected to stricter scrutiny. In those cases in which permits to take unculled oysters appear desirable the oyster commission may with advantage assume the power, which would appear to be legally within its discretion, to designate the reefs from which such oysters may be taken.

In some cases natural beds are so situated with respect to the sources of supply of fresh water that they are peculiarly liable to damage from freshets and crevasses, their oysters being frequently killed before they have had time to grow to marketable size. Such beds are often prolific spatting grounds, and the only way in which the abundant product of young oysters may be utilized is by using

them as seed for planting on private beds more favorably situated for their growth to commercial maturity.

Other beds are, under natural conditions, of little present value owing to an excessive production of oysters. Year after year there is a heavy set of spat and the beds become so crowded with oysters of all ages that all are poor, ill shaped, and practically worthless. The price which such stock will bring in the markets is so low that the expense of culling is prohibitive, and thousands of barrels of potentially valuable oysters die from starvation, smothering, and crowding.

If not denuded of shells these crowded beds may be improved by a removal of a more or less limited portion of their contents, thus leaving more room and a proportionately greater food supply for the growth of the remainder. The superfluous oysters, if not too old, and, therefore, probably irreparably stunted, serve the purpose of brood and seed stock quite as well as oysters from localities naturally more favorable, the only requisite for the production of well-favored stock of good shape being that the larger clusters be broken into small ones to allow sufficient room for the expansion of the individuals.

It would be desirable if even the culled seed oysters used for bedding purposes were taken largely from those natural beds which do not ordinarily produce fat marketable oysters of the better grades, for if they be of fair shape they will speedily fatten on good bedding grounds however inferior their original condition. This practice would make valuable many oysters which would otherwise remain so poor as to be practically unmarketable, while the oysters of the better beds would be left for the benefit of those who obtain their livelihood directly from the natural reefs.

This restriction as to the source of the seed supply is probably not feasible in its application to those planters who gather culled seed during the regular season, but it would appear applicable to many cases in which special concessions are granted, under section 19 of act 178 of 1906, permitting the fishing of culled oysters, for bedding purposes only, during the month of May. The discretion lodged with the oyster commission in the section cited would appear to convey the power to designate the reefs from which the seed oysters may be obtained. This provision of the law at present applies solely to the waters east of the western boundary of Plaquemines Parish, but it could be extended with profit to other waters of the state, provided that the permits be granted with discrimination and with due regard to the considerations just set forth.

The foregoing discussion concerns, principally, the conservation of the natural reefs. There are, in addition, several highly important suggestions relating to the future welfare of the planted beds.

SUGGESTIONS CONCERNING SURVEYS.

The first of these applies to the manner of making and recording the surveys of leased bottom and is made with a full understanding of the great difficulties confronting the surveyors in the conduct of their work. The oyster regions of the state are almost wholly in an intricate system of bays and bayous lying in the midst of a flat and topographically featureless expanse of salt marsh and prairie. The land is rarely more than a foot or two above high-water mark and is almost devoid of trees and conspicuous distinctive marks of any kind. For a large part of the area there are no even approximately satisfactory maps or charts. The work of the United States Coast and Geodetic Survey has been confined almost entirely to the outer coast, which alone is of importance from a viewpoint of navigation, although in a few places, as in the St. Bernard marshes, Barataria Bay, and, more recently, in Terrebonne Bay, the work has been carried some distance inland. Many bodies of water of more or less importance in the oyster industry are not shown on any maps published, many others are so incorrectly laid down as to be practically or absolutely unrecognizable, and on some maps there are shown bodies of water which do not exist.

Confronted by these serious difficulties, the lack of comprehensive surveys and authentic maps, and the paucity of conspicuous permanent landmarks, the surveyors in many cases have been at a loss to prepare plats of much value as matters of permanent record. The corner marks of the leaseholds are frail stakes standing in the water, where they are subject to the erosions of destructive marine organisms and dislodgment by gales and collisions with passing boats. They must be frequently replaced, and are of no value as final points of reference.

In the great majority of cases important corners can be "tied up" to no permanent natural objects, and they are located with respect to bearings and angles taken to tangents of points of land. As is well known to those familiar with the region, many of these points are so similar to one another that it is difficult to recognize the descriptions and, moreover, they are undergoing constant erosion from the waves. Narrow strips of land are converted first into islands and then eventually disappear entirely and within a few years may become absolutely useless for topographical reference. At the present time, with the leaseholds comparatively few and generally more or less isolated from one another, the matter is not of grave immediate importance, the chief desideratum of confining the lessee to an area no greater than that to which he is entitled being easily attained. The nice location of a man's 10 or 20 acres is of little present moment, provided that he pays the rental on the full area occupied.

If, however, the oyster-planting industry of the state assumes the ultimate magnitude to which the natural advantages entitle it, the defects in the surveys will lead to endless trouble and dispute. The best bottom will be in demand, the leaseholds will become congested in favorable localities, and their boundaries will have to be jealously guarded, especially when the bottoms hold a valuable crop. Should the grounds become as valuable as some of those in Rhode Island, for instance, the matter of their exact location will assume importance, and in the controversies that are sure to arise between adjoining lessees on account of the necessarily impermanent nature of the water boundary marks it will be highly essential to have for final reference and adjudication permanent landmarks which can not be questioned. With the surveys as now made and platted the time will come when neither surveyor, judge, nor jury can intelligently pass on some of the controversies that may arise.

The theoretically correct solution of this prospective difficulty would be a topographical survey of the oyster regions, with permanent " monuments " at all, or at least the important, triangulation stations. The whole system of leaseholds could then be brought into relationship and the danger of overlapping and conflicting grants would be eliminated. The water corners would be trigonometrically referred to the established landmarks and the controverted boundaries could be at any time readily redetermined. A survey of this character would be expensive, but if properly made it would have enduring value. The survey of the Maryland oyster grounds now being made through the cooperation of the federal and state governments will be available for all time, with occasional replacement of displaced or destroyed triangulation monuments. In the development of the oyster industry its value will yearly grow more apparent.

In the absence of an elaborate survey such as that outlined, something of permanence could be given to the present surveys if they were correlated with durable landmarks established in the marshes. Drain tiles, sunk for the greater part of their depth and filled with concrete, appropriately marked at the top, located at sufficient distances from the shore to reduce their liability to being washed away, would make excellent marks if they were included in the plats of the survey. From time to time, as they became more generally distributed, the different groups could be connected by triangulation and eventually cut in with the accurately established triangulation stations of the Coast Survey. This would result in the gradual establishment of a chart of the most important oyster-culture regions and give some permanence to the surveys of the individual holdings. It would require the expenditure of some additional labor and care on the part of the field surveyors and general supervision by the engineer of the commission. The slight additional cost of the sur-

veys over the present charges should be borne by the state rather than by the lessee, and in the interest of the future some of the surplus revenue of the oyster commission could be well devoted to such work.

That the difficulty of lack of accurate charting is not an imaginary one is shown by the experience of other states. In Maryland there have been found plats and descriptions of leased oyster bottom which were absolutely impossible of recognition, and to confirm the grants as required under recent legislative enactment it was necessary to run new lines arbitrarily. When Connecticut took charge of the oyster grounds of Long Island Sound the same difficulty was encountered. Many of the leaseholds could not be located from the surveys, and much time and money was expended in reconciling, usually by compromise, the conflicting claims of adjoining lessees. Recently Delaware, with its comparatively small area of leased bottoms and well-surveyed shores, has been compelled to admit that the leaseholds can not be located from the descriptions, and has undertaken an accurate triangulation, the establishment of permanent reference marks, and a resurvey of the whole area of leased bottom. Louisiana's oyster industry is younger than those of the states mentioned, and conflicts and uncertainties in the location of private holdings have not yet become pressing, but in view of the astonishing development of oyster planting in the state the time is not distant when the matter will become of commanding importance.

EXPERIMENTS IN OYSTER CULTURE.

Mention has been made previously of the methods of oyster culture in Louisiana and the comparative insignificance, at present, of cultch planting. The advantages, disadvantages, and ultimate limitation of seed planting, unsupplemented by the other method, have been briefly indicated.

The planting of seed oysters from the natural beds owed its preponderance originally to the ease with which the stock could be obtained and the controlling difficulty of obtaining shells and other cultch, but at present it can be explained in many places solely by that conservatism of the planters which inhibits their departure from a known method to adopt one with which they are not familiar.

In the region east of the Mississippi River the supply of seed on the natural reefs is still large, and in many cases the beds produce oysters which are fit only for that purpose or for canning. This is particularly true of California Bay and contiguous waters in Plaquemines Parish.

West of the Mississippi the conditions are wholly different. In Plaquemines, Jefferson, and Lafourche parishes there are practically no natural beds, and for many years there have been none from which

any considerable supply of seed could be obtained. At the time of the examination of 1898 the beds on the east side of Timbalier Bay, in Lafourche Parish, were approaching exhaustion and they are now negligible commercially. In Terrebonne Parish many of the natural beds existing in 1898 have practically disappeared, and most of the others have become depleted to an extent that makes the procuring of a sufficient supply of seed a grave problem with the planters. Terrebonne Parish formerly supplied the seed for most of the planting beds of Plaquemines Parish west of the Mississippi River, but the supply now comes wholly from the beds east of the river. The seed oysters planted in Jefferson Parish come from the same source, the time consumed in going to and returning from the seed beds often being equal to that required to tong a cargo. It is evident, therefore, that the experience of Louisiana will be like that of other oyster-producing states, where a dependence for seed upon the natural beds eventually produced a scarcity which more or less seriously interfered with the growth of oyster culture.

Louisiana, however, has a material advantage over most northern states in this, that almost absolute dependence can be placed upon procuring a set of spat every year, provided proper materials are supplied as cultch. It was to demonstrate these facts and to determine the possibilities of this method of oyster culture in several parts of the Louisiana coast that the following experiments were conducted by the Bureau of Fisheries at the request of the state oyster commission.

Work was begun in November, 1905, when the senior author made an inspection of the coast as far west as Terrebonne Bay and selected locations for the experimental work. It was determined to begin the investigations at Three-mile Bayou and Falsemouth Bay in St. Bernard Parish, at Tambour Bay and near the mouth of Bayou St. Denis in Jefferson Parish, and at Seabreeze, in Terrebonne Bay, close to a cut-off leading into Bayou Terrebonne. At this time there were no known natural beds in Jefferson Parish, and to supply breeding oysters for the experiments the Louisiana Oyster Commission in January, 1906, deposited about 50 barrels of unculled stock each at Tambour Bay and Bayou St. Denis. The other sites selected were in proximity to oyster beds and the deposit of brood oysters was unnecessary.

JEFFERSON PARISH.

That the southern half of Barataria Bay was formerly a productive oyster region is attested by the statements of the inhabitants and the great bank of shells on the former site of the packing house, but the beds were exterminated by overfishing, probably coupled with natural causes, and at the time of the investigation of 1898

they were recognizable only by the presence of old shells more or less buried in the mud. In a few places there were occasional old oysters, but no spat whatever. None of the natural beds appear to have been extensive, and their extermination was readily accomplished by the reckless methods employed in the fishery, particularly under the changes in the salinity conditions which were then in progress.

A few oysters for local use were annually planted close to Grand Isle and at Grand Bank, and in Bay Coquille some were bedded for market, but in neither place was there any indication of a volunteer growth of young.

There was no evidence of the existence of beds at any time in the upper part of the bay, and persons familiar with the region stated that none had ever been known north of the Quartelle, a group of four small islands near the center of Grand Lake. About 1903 a small bed was found near Bayou St. Denis, but this was quickly depleted and a careful search in 1905 failed to disclose any oysters whatever on its site.

In 1898 the whole upper part of the bay was of low salinity, and it was stated that during spring and early summer the water was often nearly or quite fresh for months, and it was manifest that the conditions were not favorable for oyster growth. With the improvement of the levee system the volume of fresh water discharging into the bay has markedly decreased, and the general salinity of the whole region has correspondingly increased. The closure of the head of Bayou Lafourche has had a very marked influence in Bay Coquille and contiguous waters, where the density of 1.0038 observed in March, 1898, has increased to an average of about 1.0186 during the same season of recent years, and at Leeville, immediately on the bayou, where the water was formerly always fresh, a set of oysters has several times occurred. In Bay Tambour the observed density in March, 1898, was 1.0094, while the average for approximately the same season in 1906 to 1908 was 1.0151. In Bay des Islettes there is noticeable a slight rise in salinity, but nearer the sea, as at Grand Isle, there appears to be little or no change.

Nearer the mouths of Grand Bayou and Bayou St. Denis we have no early data concerning the saltness of the water, though it was stated in 1898 to be almost constantly fresh. During a crevasse in the spring of 1907, when the conditions were such as frequently, if not normally, existed in former times, this water was practically fresh for a considerable period, though the average density during other recent years has been about 1.0110. Little Lake, about 10 miles inland from the mouths of the bayous, where the water was formerly fresh and inhabited by large-mouth black bass, now contains oysters, undoubtedly derived from fry discharged from the experimental beds at the mouth of Bayou St. Denis.

It is evident, therefore, that the zone of water favorable for oyster growth, and especially for the welfare of the spat, has moved generally inland during recent years, owing to artificial changes in the drainage system resulting from levee improvements. We have made the same observations in Terrebonne Parish, where oysters are established in bayous which formerly carried water fresh at all times.

The region nearer the coast is not so salt as of itself to inhibit the growth of oysters, but it has become sufficiently so to be especially favorable for the development of a very destructive enemy of the oyster, the snail or borer, *Purpura*, which kills the spat, though the adults are immune by reason of their heavy shells. On the other hand, the more inland waters have become sufficiently salt for the oyster, but are still too fresh to furnish the environment required by the borer. Of the two localities in which experiments were conducted in Barataria Bay, Bay Tambour falls within the first region and Bayou St. Denis in the second. In Bay Tambour, where natural beds existed until exterminated a number of years ago by overfishing, possibly supplemented by changes in salinity, the set on the experimental beds was as heavy as at Bayou St. Denis, though the spat were killed by borers within a month or two. The adult oysters were unharmed, and at Bayou St. Denis neither young nor adults were molested and no borers were found.

It is evident from the details of the experiments hereafter recounted that practically the entire bay may be utilized for oyster culture wherever suitable bottom can be found or made. North of a line running from the mouth of Bay Baptiste to about the mouth of Bayou du Fone shells and other cultch may be planted with very little risk of having the spat killed by borers and with every assurance that a strike will occur each season. This part of the bay covers about 8,000 to 10,000 acres. Though the bottom was not tested over much of this area it is probable that a considerable part of it is too soft for use without special preparation, though most of it will doubtless be utilized eventually.

South of the line above mentioned is a region, embracing the greater part of the bay, where spat culture can not be attempted without considerable risk or, usually, the certainty of meeting disaster through the depredations of the borer. In some localities the drumfish is likely to prove destructive, but where this danger does not occur oysters not less than 1½ or 2 inches long can be planted with the surety that they will grow into fine stock, commanding a good price in the New Orleans market.

Before the experiments were begun there was some objection to the selection of Barataria as a field of operations, on the ground that there was no industry at that place which could be benefited, and that

the time and effort necessary could be expended to better advantage elsewhere. The answer to this objection was obvious, as the purpose of the work was to develop an industry where none existed, and not merely to supplement what had been already begun. The vindication of the selection was apparent before the experiments were a year old, and the commercial response to the experimental results was immediate.

Prior to the beginning of the experiments there had been issued in Jefferson Parish, which includes the waters under discussion, 7 leases, aggregating 75 acres, and of these 4 had lapsed. From the time the early results of the experiments first became known until April, 1908, there were issued 138 leases, covering 710 acres, yielding to the state an immediate annual income of $1 per acre, and the leases immediately surrounding the small experimental plant at Bayou St. Denis so hemmed it in that it was necessary to go on private bottoms in order to carry on the final stages of the work.

Many of these leaseholds have not yet become productive, but during the year ended April 1, 1909, there were shipped from Barataria Bay 29,874 barrels (97,090 bushels) of oysters, valued at $1.60 per barrel on the beds, and paying 40 cents per barrel transportation charges to New Orleans. Practically before the experiments were concluded this region, hitherto producing nothing, was yielding to the state an annual income of $906.22 for rentals and $896.22 for the privilege tax of 3 cents per barrel, a total of $1,804.22 per annum. A more important phase of the results is that the planters during the same year received an income of $47,798.40 and the transportation companies $11,949.60, a total of $59,748. Men formerly in debt have become independent, working no harder than they previously did as farmers or fishermen.

Viewed from the standpoint of the consumer, the results of the work have been equally significant, adding to the state's food supply oysters enough to furnish 600,000 meals of 1 pound each. The region has excellent possibilities, and the oyster industry should undergo great expansion during the next few years. The oysters are of fine quality, fat and shapely, and in 1899 found a steady market when the product of the natural reefs went begging at one-fourth the price.

BAYOU ST. DENIS.

This experimental plant is located in Barataria Bay, about one-third mile from the mouth of Bayou St. Denis, on the edge of an old reef of dead clam shells, in about 6 feet of water. It was selected as being outside of the limits of the old oyster growth, and well adapted to test the validity of the opinion that the upper part of the bay had become adapted to the growth of oysters, and that no place

OYSTERS, AVERAGE SIZE, 1 AND 2 YEARS OLD RESPECTIVELY, GROWN ON OYSTER SHELLS AT BAYOU ST. DENIS, LOUISIANA.

[Figures natural size.]

on the coast of Louisiana offered superior advantages for oyster culture. The currents are strong, both on the experimental beds and for a considerable distance in all directions on average tides at half ebb and half flood, ranging from about two-thirds to 1 mile per hour. This insures a good circulation of water, the frequent renewal of the food supply, and the practical certainty of a good set of spat upon material exposed at the proper season.

The specific gravity of the water, which is a measure of its salinity, ranged from 1.002 during the crevasse of 1907 to 1.017, or, in other words, from practically fresh water to that which was essentially a mixture of two parts of sea water to one of fresh. The average for the whole period of the experiment was 1.009, or, if we exclude the period of the crevasse, it was about 1.012. This salinity, which appears to be maintained quite uniformly during the oyster-shipping season, is well adapted to producing oysters of excellent flavor for "counter stock."

Prior to the experiment it had been feared that in case of a crevasse discharging through any of the bayous opening into the head of the bay the water would become so fresh as to kill the oysters planted on this bed. In the spring of 1907 the levees broke at Live Oak and a great volume of river water coursed down Bayou St. Denis, and especially Grand Bayou, keeping the water on the experimental beds almost fresh during most of May and June. The only effect was practically to prevent a set of spat during these months, the adult oysters being unharmed. This was a rather severe test, and it demonstrates that but little or no harm is likely to occur from ordinary crevasses discharging into the drainage basins of bayous opening into the head of the bay, and that unless the freshet should continue as late as September the set of young would not be prevented.

The bottom in this vicinity is moderately hard, owing principally to the large numbers of clam shells embedded in the mud. Over an area of several hundred acres surrounding the experimental plant the bottom is in many places more or less devoid of buried shells and somewhat softer, but well within the limits suitable for oyster culture. Still farther removed from the experimental plant the character of the bottom is unknown, but there is probably a considerable area immediately available and undoubtedly much more that a moderate coating of shells would make suitable.

With use all of this area would soon become harder from the collection of shells in and on the mud, and eventually would present characteristics similar to those found on the younger natural reefs. This phenomenon is well known to planters and oyster men, and it is a common practice in Louisiana to "shell" the bottom so as to establish on the soft mud a suitable foundation for the deposit of oysters pending the collection of a full cargo for market.

The observations made in this locality during a period of three years indicate an abundance of food, and the strong currents already mentioned assure its distribution over a wide area. Oyster food is more abundant in this locality than at any other of the 40 stations at which observations were made, excepting only the middle of Barataria Bay and Falsemouth Bay. The following table shows the details of the data relating to the observations on the organisms which constitute the greater part of the oyster's food, together with the salinities and temperatures of the water at the time the specimens were taken.

FOOD CONTENT, SPECIFIC GRAVITY, AND TEMPERATURE OF WATER AT BAYOU ST. DENIS.

Date.	Specific gravity.	Temperature.	Food organisms per liter of water.	
			Number.	Volume.
1906.		°F.		Cu. mm.
April 24	1.0066	74.3	10,000	0.160
26	1.0081	77	14,000	.308
May 25	1.0114	79.7	13,000	.189
28	1.0115	83.3	12,000	.352
June 28	1.0115	77.9	18,000	.126
November 5	1.0170	68.0	7,800	.140
1907.				
January 8	1.0128	74.0	3,000	.153
March 16	1.0010	70.0	5,600	.301
April 15	1.0105	73	24,000	1.321
16	1.0126	72.5	21,000	.979
29	1.0095	80.0	6,300	.369
May 21	1.0021	79.0	3,500	.163
June 25	1.0028	84.0	8,000	.206
27	1.0028	84	7,350	.346
December 11	1.0060	55	5,000	.190
1908.				
May 27	1.0105	86	4,200	.163
29	1.0106	85	8,250	.318
July 7	1.0099	83	12,750	.346
1909.				
January 27	1.0133	72	9,000	.280
Average	1.0090		10,145	.337

During the period of three years in which the work continued no oyster enemies were observed on the plantation excepting a growth of mussels which appeared during the freshet of 1907 but disappeared later when the salinity of the water became higher.

The experiment began in January, 1906, when the Louisiana Oyster Commission, at the request of the Bureau, planted about 50 barrels of unculled oysters to serve as brood stock. On April 24 and 26 following, the first cultch was planted on three areas, each one-twentieth of an acre in extent, 50 bushels of material being deposited on each. On one square oyster shells were spread broadcast, on another they were deposited in heaps of 2 bushels each, and the third was planted with clam shells broadcast. On May 25 and June 28 the operations

OYSTER, AVERAGE SIZE, 33 MONTHS OLD, GROWN ON OYSTER SHELL AT BAYOU ST. DENIS, LOUISIANA.

[Figure natural size.]

were repeated on two adjoining areas of the same size, the quantity of material in these cases being reduced to 30 and 20 bushels, respectively.

During 1907 the plants with oyster shells were made April 16, May 21, and June 25, and a single plant of clam shells was deposited on May 21. Thirty bushels of oyster shells were spread, each, on July 26, August 26, September 26, and October 29.

In 1908 oyster shells were deposited broadcast and in piles on April 20 and May 27. There were in all 25 plantings, and on every one excepting that of October 29, 1908, a set of spat was secured before the end of the year in which the shells were deposited. The plants of April, May, and June, 1908, remained barren during the period in which the crevasse water was pouring over the beds, but after this was stopped and the water grew more salt a small set appeared on these shells, a larger one being prevented probably by the silt deposited by the flood waters.

The results demonstrated that under usual conditions a strike of young oysters is almost certain to occur upon shells or other cultch deposited between April 1 and October 1, a period of six months. Even in the case of the October plant the shells, notwithstanding their long exposure, were still in condition to receive a small set in the following spring.

The proportion of shells to which young oysters attached within a month after they were planted varied from 40 to 90 per cent, those planted in May, June, and July being usually most effective as spat collectors. The shells spread broadcast were more efficacious than those deposited in piles, though the latter usually became leveled by the waves after the lapse of a few months. The clam shells were less effective than oyster shells, probably in part because, being lighter and smaller, many of them were carried by currents and waves away from the squares on which they were planted. From 1 to 5 young oysters were found attached to the oyster shells at the end of one year, the average being about 2 or 3 to each. At a later date the shells became more or less disintegrated and broken, resulting in a natural culling which freed the oysters from their attachment. After the lapse of a year most of the clam shells bore but single oysters, though there were occasionally two attached.

The experiments indicate that from 400 to 600 bushels of shells per acre can be advantageously planted on firm or moderately firm bottom. On soft bottom more should be used, as some will become buried in the mud. Later, when there are more breeding oysters in the vicinity and the waters become more thoroughly charged with fry, the set on individual shells will become heavier and the quantity of material planted should be reduced to prevent overcrowding. If the set should become very heavy clam shells or

broken oyster shells may prove advantageous, and it may prove good policy to cull the oysters at the end of the first eight or ten months so as to permit them to grow to good shape. At present this is unnecessary. In many cases the shells and débris culled off, if taken ashore and weathered, would suffice for planting other areas.

The rate of growth of oysters attaching to oyster shells was more rapid than of those striking on clams, probably because they were raised higher above the bottom and therefore more favorably situated for obtaining a supply of food. This fact and the average sizes attained by the oysters at different ages are shown in the following table:

AVERAGE LENGTH OF OYSTERS ATTACHED TO PLANTED SHELLS AT DIFFERENT AGES (ONE TO THIRTY-THREE MONTHS).

Ages.	On oyster shells.	On clam shells.	Ages.	On oyster shells.	On clam shells.
	Inches.	*Inches.*		*Inches.*	*Inches.*
1 month	0.4	0.4	6 months	1.4	.....
2 months	.5	.....	12 months	2.8	2.2
3 months	.7	.....	24 months	3.5	2.8
5 months	1.1	.....	33 months	4.0	3.25

This table assumes the ages of the oysters to date from the time of planting the shells, but as the strike is ordinarily distributed over several months, the ages, excepting of the youngest, are somewhat overestimated. It will be observed that at the end of the first year the planted oyster shells bore oysters, whose average size was somewhat above the minimum market limit, and many of them were between 3 and 3½ inches long. At 2 years of age they were between 3 and 4 inches long and averaged 3½ inches, while in less than three years from the date of planting all of them were between 3½ and 5 inches long and averaged about 4 inches. These oysters were all of fine shape, with rather heavy clean shells, and in small clusters or single, requiring very little culling to fit them for market. Those raised on clam shells, though of smaller size, were of particularly fine shape and all single. At an age of 33 months they ran from 500 to 525 oysters to the barrel of 3¼ bushels, while those grown on oyster shells rated between 425 and 450.

During most of the period of the experiment all of these oysters were fat and in fine condition for the market, and in January, 1909, when the work was brought to a close, they were equal in fatness to the famous oysters of Lynnhaven, Va., and yielded about 5½ pints of thoroughly drained meat per standard bushel, which is equivalent to nearly 7 pints as measured at the shucking houses. The greater thickness of the shells caused them to "turn out" a smaller quantity of meats per bushel as compared with the thin shelled oysters of

OYSTERS, AVERAGE SIZE, 24 AND 33 MONTHS OLD RESPECTIVELY, GROWN ON CLAM SHELLS AT BAYOU ST. DENIS, LOUISIANA.

[Figures natural size.]

Falsemouth Bay, which they equaled or slightly excelled in fatness, but their superiority in appearance more than compensated for this. A clean, attractive-looking exterior is of importance in high-grade oysters used in the "counter" or "shell" trade, the most lucrative market which the planter can supply. The authors have been informed that the oysters left on the experimental beds have been taken up by oystermen and sold for $2 per barrel in New Orleans at a time when ordinary oysters could hardly be disposed of.

Unfortunately here, as at other of the experimental plants in the state, the authors were not able to make ultimate determinations of the productivity of the grounds, owing to the theft of most of the marketable oysters prior to the final examination. The average growth on the older sections of the planted beds in January, 1909, was but 140 bushels per acre, though examinations made in the preceding May showed that in places the density of the oysters was at the rate of between 1,500 and 2,000 United States standard bushels per acre, and a conservative estimate would place the average for the entire area at between 1,000 and 1,500 bushels or 300 and 450 barrels per acre.

BAY TAMBOUR.

The work at Bay Tambour was coincident with that at Bayou St. Denis and the same methods were followed, but the experiment was abandoned so far as the planting of cultch was concerned at the end of June, 1907.

The plant was located off the western point of a small island lying west of Bayou Andre, on the site of an extinct oyster bed, the only evidence of whose former existence is in the shells deeply buried in the mud. The currents are moderate, being perhaps of about half the strength of those at Bayou St. Denis. The water in the three years during which the observations were continued had an average specific gravity of 1.0146 and a range between 1.010 and 1.020. This salinity is considerably higher than at Bayou St. Denis, but, considering the requirements of the oyster only, is well adapted to oyster culture. Residents stated, prior to the beginning of the experiment, that the water at this place killed oysters, but, as is shown by the investigations hereafter recounted, this is an error, the mortality among the young oysters being due to another cause, although indirectly attributable to the relative saltness of the water as compared with more northerly parts of the bay. At this locality there is very little probability of loss from the effects of crevasses or from sudden and drastic changes in the saltness of the water from any cause.

The bottom in the immediate vicinity of the plantation is hard, but much of that adjoining is soft, though a considerable area could be utilized for oyster culture.

Food is abundantly produced in the waters of the vicinity, and although there is considerable fluctuation in the supply, the average of a number of observations made on the planted grounds is higher than was attained in most parts of the state. The food production in the adjacent parts of Barataria Bay is very high, and there would therefore appear to be an abundant reserve supply. The seed oysters, originally planted as brood stock, which were rough and unculled as taken from the reefs, about 2½ inches long, and planted at the rate of about 800 bushels per acre, grew rapidly and were always fat and in good condition. The various observations of the salinities, temperatures, and food production of the water are shown in the following table:

FOOD CONTENT, SPECIFIC GRAVITY, AND TEMPERATURE OF WATER IN BAY TAMBOUR.

Date.	Specific gravity.	Temperature.	Food organisms per liter of water.	
			Number.	Volume.
1906.		° F.		Cu. mm.
April 25	1.0117	74.3	16,000	0.313
27	1.0102	77.9	15,500	.329
May 26	1.0129	81.5	11,000	.262
28	1.0124	86.0	7,000	.206
June 27	1.0166	78.8	7,500	.118
29	1.0167	77.0	5,000	.060
August 20	1.0195	85	9,000	.240
November 10	1.0191	75	5,400	.185
1907.				
January 10	1.0170	68	2,000	.018
April 17	1.0203	78	6,750	.220
19	1.0175	80	10,800	.089
30	1.0158	80.6	8,100	.376
May 22	1.0097	80.6	6,000	.173
June 26	1.0113	84.2	7,200	.181
July 24	1.0136	86	10,200	.420
December 11	1.0131	53	1,500	.081
1908.				
May 4	1.0141	77	35,000	.807
July 3	1.0100	81	8,100	.259
1909.				
January 29	1.0172	68	21,750	.673
Average	1.0146		10,200	.295

About 50 barrels of rough unculled oysters from the natural beds were planted in January, 1906, and in the latter part of the following April oyster and clam shells were planted after the manner of those deposited at Bayou St. Denis, followed by two similar plants in the latter parts of May and June, respectively. In all these the apparent set of spat was light, the number of shells bearing young oysters ranging between 15 and 35 per cent of those examined, the average of all plants being about 22 per cent. By the following spring all of these young oysters had disappeared. The results of the second year's experiments were even more unfavorable, and spat transplanted from Bayou St. Denis were also killed within a few weeks.

BORERS, OR "SNAILS" (PURPURA HÆMOSTOMA), THEIR EGG CASES, AND OYSTER SPAT DRILLED BY THEM. BAY TAMBOUR, LOUISIANA.

[Figures natural size.]

It was observed that the few upper valves still adherent to the shells were perforated by small holes, and as the gasteropod *Purpura*, locally known as the "borer" or "snail," was abundant on the stakes marking the beds it was at once suspected to be the cause of the mortality. To test this hypothesis three boxes were constructed of one-fourth inch wire screening and planted on the beds on April 17, 1907; one, closed, containing both shells and borers; one, closed, containing shells alone; and the third, open, with shells only. On June 26 the contents of the boxes were examined with the following results: In the open box 18 per cent of the shells bore spat, of which several were dead, and there were 5 borers besides several fishes and crabs. In the closed box, containing shells and 12 borers, but 2 per cent of the shells bore live spat, and these were concealed either under the shells or by marine growths. In the closed box without borers 60 per cent of the shells bore live spat, averaging two to the shell. This box contained when taken up 14 very small borers which had evidently entered through the mesh.

On June 26 two closed boxes were planted, one with clean shells and 9 large borers, and the other containing shells bearing spat from one-half to three-fourths inch long, but with no borers. When taken up on September 1 the shells in the first box were devoid of spat of appreciable size, the large borers were dead, and there were no small ones. In the other box there were 17 live borers between three-eighths and $1\frac{1}{4}$ inches long which must have crawled through the mesh when quite small; there were no dead borers, but 2 per cent of the spat had survived and all of the upper valves remaining attached showed the small perforation made by this enemy.

The brood oysters planted in January, 1906, when they were between 2 and 3 inches long, at no time showed any greater mortality than was to be expected from the mere act of transplanting, and this fact in connection with the experiments just recounted shows without much doubt that the failure to obtain results from planting shells was due, not to the quality of the water, per se, but to the destructive habits of the borer. The largest spat killed was less than $1\frac{1}{4}$ inches in length, and it is safe to assume that seed oysters 2 inches long and probably as small as $1\frac{1}{2}$ inches will be immune.

The borers lay their eggs in red or purple leathery capsules about one-half inch long, attached in dense clusters to shells, stakes, and other fixed bodies in the water. The capsules are demicylinders, usually more or less curved toward the convex surface and with flattened or slightly convex free ends. Each capsule contains several eggs and the young snails escape through holes less than one-fiftieth of an inch in diameter, which they cut in the free end of the capsule.

These recently-hatched borers probably feed upon the very minute and newly-attached spat, though of this we have no certain knowledge. Growth is rapid, as is shown by the experiments with boxes. The mesh employed in these was one-fourth inch square, and the largest borer that could be pushed through measured seven-sixteenths of an inch in length. In closed boxes planted June 28 there were borers three-fourths to 1¼ inches long on September 1, an increase of from 75 to 190 per cent in length and of from 200 to 450 per cent in bulk within a period of about two months.

The difficulties in fighting a small and insidious enemy such as this are very considerable. It is wholly impracticable to inclose the beds, as is done to prevent the inroads of drumfish and similar enemies, the little snails being able to travel through the finest practicable mesh, and the only recourse is to wage unceasing warfare by destroying all borers and egg cases found. To tong or dredge the oysters especially for this purpose is commercially impracticable under the market conditions obtaining in Louisiana, and the obvious course for the oyster culturist in the more salt waters in which the borer abounds is to eschew all effort at planting shells and confine his activities to planting seed oysters at least 1½ inches and preferably not less than 2 inches long. If he does this the presence of this enemy may even prove a boon in preventing the excessive attachment of spat to the older oysters, an occurrence which in some places on our coasts renders it impossible to grow oysters fit for market.

As to the rate of growth of oysters in the earlier stages at Bay Tambour little can be said for reasons which are apparent. The growth of the seed oysters planted at the beginning of the experiment was very satisfactory. In April, 1906, measurements of the length of a number of these averaged 2.6 inches. In June, 1907, the average length was a little less than 4 inches, and in May, 1908, it was about 5 inches. In less than two years, therefore, these oysters doubled in length, and despite the fact that they were not culled, the clusters automatically broke apart to some extent, owing to the disintegration of the shells to which they were attached, and there was a corresponding improvement in shape. The growth here was about the same as at Bayou St. Denis, and indicates that however unsuitable this part of the bay may be for spat culture, owing to the reasons before set forth, there is an excellent opportunity for the establishment of an important and profitable industry in growing oysters from seed.

The results attained by the work at Bay Tambour are applicable to all of that half of Barataria Bay lying nearer the gulf, our investigations having shown the conditions to be essentially similar throughout that region. During the last year or two of the experiments a

OYSTER, AVERAGE SIZE, GROWN IN 29 MONTHS FROM SEED ABOUT 2½ INCHES LONG.
BAY TAMBOUR, LOUISIANA.

[Figure natural size.]

considerable area of bottom was taken up by planters in this region and most of the oysters shipped during the oyster season 1908–9 were grown on these leaseholds. It is understood that the business was very profitable and that the supply of Barataria oysters, despite their lack of previous reputation, was unequal to the demand. They were all contracted for at a price equivalent to $1.60 per barrel on the beds and could have commanded a higher price in the open market. It is the opinion of the authors that they are among the best produced on our entire coast.

ST. BERNARD PARISH.

St. Bernard Parish embraces the most productive natural oyster region in Louisiana and at the present time produces about 40 per cent of the total yield of the state. Its oyster beds lie principally in what is known as the "Louisiana marshes," a low uninhabited expanse of sea marsh and prairie covering an area of between 400 and 500 square miles between Mississippi, Chandeleur, and Isle au Breton sounds. This region is cut up into innumerable islands by an intricate system of bays and bayous, most of which contain natural oyster beds, described and platted in some detail in the report of the investigations in 1898, previously alluded to.

In the season of 1906–7 St. Bernard Parish produced upward of 1,000,000 bushels of oysters, but in the following season the production was somewhat smaller. Although there have been some attempts at oyster culture and there are extensive leaseholds, most of these oysters came from the natural beds.

In 1898 there were no leases of bottom in this region and few were granted prior to 1904, when what was practically the present oyster law went into operation. In the next five years 66 leases were issued, and in 1908 there were in force 48 leases, aggregating 5,395 acres, of which 44 leases and 4,456 acres were in the Louisiana marsh and 4 leases and 939 acres in Lake Borgne.

Many of the leases are for plots less than 20 acres in extent, but 9 individuals, firms, and corporations have holdings of between 100 and 1,000 acres each, covered by 25 leases aggregating 4,858 acres. These have been planted in part with seed oysters and shells, but the business has not yet proved very profitable owing mainly to the fact that the set of spat has been so heavy as to cause overcrowding of the beds with the consequent failure of the oysters to fatten and grow to good shape.

The salinity of the water varies considerably in the several parts of the region under discussion, being as a rule lower in Lake Borgne and the waters closer to Mississippi Sound and higher toward Chandeleur Sound and the southern part of the parish. This is shown in

the following table of the specific gravities observed during four calendar years:

SPECIFIC GRAVITY OBSERVATIONS IN WATERS OF ST. BERNARD PARISH.

Locality.	1906.	1907.	1908.	1909.
Lake Borgne	1.0068	1.0041	.....	1.0051
Falsemouth Bay	1.0074	1.0058	1.0016	1.0075
Three-mile Bay	1.0070	1.0054	1.0041	1.0083
Treasure Bay	1.0106	1.0096	.....	1.0125
Big Mussel Bay	1.0119	1.0113	.....	1.0128
Eloi Bay	1.0125	1.0150	.....	.....
Saw Bay	1.0167	1.0155	.....	1.0159
Blind Bay	1.0193	1.0162	.....	1.0170
Caligo Bay	1.0200	1.0192	.....	1.0159

In the northern localities the water is rather too fresh to produce palatable oysters for shell stock, though this does not affect their utility for shucking and canning purposes. In this region, as a whole, oyster food is abundant, a large number of observations indicating that it is about equal in this respect to that part of Placquemines Parish adjoining it, east of the river, and only exceeded by the waters of Barataria Bay. It is considerably richer than either Terrebonne Parish or that part of Placquemines Parish, as a whole, lying about Bay Adam, Bayou Cook, and Bastien Bay. The richest waters are Falsemouth Bay and Treasure Bay and the poorest those lying near Three-mile Bayou.

The depth of water ranges generally from 3 to 6 feet in the bays, but is often much deeper in the bayous. The bottoms are generally soft, in many places too soft to be used for oyster culture without special preparation, but there are also considerable areas of hard or moderately hard mud. Even the softest places may be made available by strewing them with shells, sand, or gravel, but there is undoubtedly enough naturally suitable bottom to make this unnecessary for some time to come.

For experimental purposes in this region there were selected two localities not far apart but differing in all factors involved excepting that of salinity. The localities, the experiments, and the results are described in the following:

FALSEMOUTH BAY.

Falsemouth Bay lies in the northwestern part of the Louisiana marsh and communicates with Mississippi Sound by means of Nine-mile Bayou, a channel from 100 to 300 yards in width, and with an average depth of about 24 feet. A smaller, though deep, bayou leads to Nine-mile Bay to the eastward, and there is wide communication at the southeast end with the lower part of Nine-mile Bay and the upper part of Treasure Bay.

Writing in 1898 one of the authors said:

> It seems probable that the scarcity of oysters in Falsemouth Bay is due in large part to the lack of suitable places of attachment for the spat, and if this be so there is but little doubt that productive beds might be established by planting shells, together with a sufficient number of brood oysters to furnish fry. We found here the largest area of firm bottom discovered anywhere within the limits of the reconnoissance. In most other parts of the district the hard bottom is distributed in small patches lying like islands in the midst of soft mud, but in Falsemouth Bay shells and seed could be deposited almost anywhere without danger of becoming engulfed. The amount of oyster food is larger than almost anywhere else in the district, the average number of diatoms in each liter of water 1 foot above the bottom being about 22,000. The extreme fatness of the oysters is also ample evidence of the abundance of food, although, of course, the amount available for each individual would become less if planting were extensively undertaken.

Although, as previously stated, considerable areas of bottom have been leased in contiguous and neighboring waters, the recommendations just quoted have borne no fruit, and it was with the purpose of testing their validity that experiments were undertaken at this place.

The site selected for the experimental work was in a small bight in the northeastern part of the bay, about one-third of a mile from the mouth of a deep cut-off running into Nine-mile Bayou. The water has a depth of about 3½ feet at low tide.

Pirate Point on one side and a chain of several small islands on the other form a somewhat funnel-shaped area with its small end opening into Nine-mile Bayou and its large end communicating with Treasure Bay and the waters to the eastward. The tidal flow entering and leaving the interior waters in large part passes through this area, and, as the bayou communicating with Mississippi Sound is wide and deep, the currents, especially in the northern part, where the plantation is located, are moderately strong and constant. Measurements on the planted beds indicate a current of about one-half mile per hour on moderate tides, and observation showed the rate to be approximately uniform over an area of several thousand acres in this vicinity and probably over the entire eastern part of the bay. The importance of this fact need not be indicated to practical oyster planters.

The salinity of the water is comparatively low, rendering the oysters rather insipid when used as "shell stock," but not interfering with their value for the shucking trade. During the spring and summer of 1908 the water was nearly fresh, its specific gravity ranging about 1.0020, but at all other times during the experiment it was somewhat higher, fluctuating between 1.0030 and 1.0092, with an average of 1.0056 for the entire period and about 1.0070 in the oyster season. During the three years of the investigation there was

nothing to indicate any mortality among the oysters due to the low salinity of the water.

The floor of Falsemouth Bay is level and clean of all rubbish and débris. The bottom is quite uniformly composed of hard mud, much like that of the surrounding land, though there are occasional small patches of softer consistence. The bay has an area of about 11 square miles, and over practically all of it oysters and shells may be planted without danger of being engulfed. There are not now, nor, apparently, have there ever been, any natural reefs, and the few very scattering oyster growths observed in 1898 seem to have been exterminated.

In oyster food Falsemouth Bay was found to be one of the richest places in Louisiana in 1898, and the results of the present examination show that it retains this rank. The average oyster-food content of its waters from May, 1906, to January, 1909, was higher than that of any other locality observed, excepting only the middle of Barataria Bay. Falsemouth Bay and Bayou St. Denis, in Jefferson Parish, were about on an equality. The following table shows the fluctuations in the observed food supply, together with the specific gravities and temperatures of the water at various times during the course of the experiments:

FOOD CONTENT, SPECIFIC GRAVITY, AND TEMPERATURE OF WATER IN FALSEMOUTH BAY.

Date.	Density.	Temperature.	Food organisms per liter of water.	
			Number.	Volume.
1906.		°F.		*Cu. mm.*
May 9	1.0092	72.5	38,000	1.594
June 10	1.0064	86.0	5,500	.201
July 17	1.0066	82.0	8,000	.216
1907.				
January 5	1.0084	64.0	4,000	.094
April 12	1.0059	72.0	9,000	.316
May 16	1.0030	77.0	14,400	.436
June 9	1.0028	84.2	7,200	.291
July 7	1.0079	87.8	2,500	.067
December 13	1.0070	54.5	5,400	.226
1908.				
April 23	1.0020	79.0	7,200	.372
June 5	1.0030	87.0	3,750	.173
July 12	1.0029	85.0	7,500	.346
1909.				
January 24	1.0075	64.4	4,800	.119
Average	1.0056		9,020	.342

No oyster enemies whatever were observed in this locality. The water is too fresh for the borer ever to become troublesome, but the drumfish, which operates in water of all degrees of saltness, might make occasional forays if oysters were numerous enough to be attract-

OYSTERS, AVERAGE SIZE, 1 YEAR OLD, GROWN ON OYSTER SHELLS AT FALSEMOUTH BAY LOUISIANA. THE UPPER FIGURE SHOWS THE CHARACTERISTIC DEEP CUP

[Figures natural size.]

ive. There were a few mussels and barnacles attached to the planted oysters, but they were not abundant enough to be troublesome.

The experiments in Falsemouth Bay began on May 6, 1906, and subsequent plantings were made on June 10 and July 17, 1906; April 12, May 16, June 9, and July 7, 1907, and April 23 and June 5, 1908. The final examination was made on January 23 and 24, 1909. In all, 14 plantings were made, of which 2 were of clam shells, both whole and broken, spread broadcast, 9 were of oyster shells, broadcast, and 2 of oyster shells in piles.

The quantity of oyster shells planted varied from 200 to 1,000 bushels to the acre and the clam shells from 200 to 600 bushels per acre. The clam shells, which were hardly more than 1¼ inches in diameter, were obtained from neighboring shell banks, and many of them were fragmented by wave action. On the whole they did not prove satisfactory, the entire shells being scattered by the waves and the fragments soon becoming so covered with silt and mud that they offered very imperfect places for the attachment of the oyster spat. The oysters produced on these shells were all single and of fine shape, but, as was also observed at Bayou St. Denis, they grew more slowly than those attached to oyster shells. If somewhat larger and heavier clam shells can be conveniently obtained, they would doubtless make excellent cultch, but the use of the local supply can not be recommended, except for the purpose of hardening the small areas of soft bottom which occasionally occur in the bay.

From 60 to 90 per cent of the oyster shells were found to bear small oysters at the end of the season in which they were planted, the spat striking in every month from April 11 to July 17. Doubtless shells planted a month earlier and a month or two later would prove as effective as in Barataria Bay, but there is no positive evidence of the fact in this locality. The average number of oysters attached at the end of the season, after they had attained a length of 1 to 2 inches, was from two to three per shell, there being some larger clusters and a good proportion of single oysters.

The set was much lighter than in the adjacent waters of Three-mile Bayou, owing undoubtedly to the relative remoteness of considerable beds of spawning oysters. This is of considerable advantage in avoiding crowding of the growing oysters and promoting a better shape and condition. Should the bay be used extensively for planting shells it will probably be found that the set will be much heavier than now occurs, and to secure the best results it may be necessary to break up the larger clusters produced so as to give the individual oysters room to grow and fatten. Under the present conditions from 400 to 500 bushels of cultch per acre appears to be the best quantity to plant, but with any heavy increase in the number of

spawning oysters in the vicinity, as from extensive planting operations, this quantity may probably be advantageously reduced.

The yield per acre of the planted beds could not be determined, as prior to the final examination the oysters proved too attractive to the tongers, and most of the plantation was despoiled of both oysters and shells. Certain small areas which had been overlooked by the marauders, however, indicated that the growth on some sections at the end of about thirty months from the time the shells were planted was probably between 1,000 and 1,500 United States standard bushels per acre. The oysters were of good shape and very fat. Those grown on oyster shells were from $3\frac{3}{4}$ to $4\frac{1}{2}$ inches long and averaged about 200 to the bushel, while those on clam shells were of even finer shape and averaged about 3 inches in length. The shells were rather thin, but somewhat thicker in the clam-shell set than on that attached to the oyster shells, in the former consituting 70 per cent of the total volume of the unopened oyster, and in the latter 55 per cent. The oyster-shell set averaged about 200 oysters to the standard bushel, considerably more than oysters of the same length at Bayou St. Denis, the difference being due to the much thicker, heavier shells of the latter. These oysters, taken "the run of the bed," without selection, shucked slightly over 7 pints of completely drained meats per standard bushel. The single oysters grown on clam shells were relatively fatter, but owing to their thicker shells would "turn out" no more meat per bushel.

Taking all factors into consideration, Falsemouth Bay appears to possess very great advantages for planting operations on a large scale in connection with the shucking trade, but the salinity is too low and the shells are rather too thin, excepting those grown on clam shells, for raising "shell stock" or "counter" oysters.

The bottom is almost everywhere firm enough for planting, the rate of growth is rapid, the shape of the oysters is good, and the relatively thin shells, taken in connection with the plumpness of the meats, insures a large yield of shucked oysters per bushel, effecting economy in transportation and opening. The meats are also attractive in appearance and should command a good price as "extra selects."

The only drawback is that the shells are in some cases rather brittle and may break in opening, but this defect is more than counterbalanced by the large quantity of meats "turned out" per bushel.

Either seed oysters from the natural reefs or cultch may be planted to advantage. In the latter case it is not unlikely that, if a considerable part of the bay is converted into oyster bottom, the set of spat may be so heavy as to require the clusters to be broken up at the end of the first season's growth.

OYSTER, AVERAGE SIZE, 33 MONTHS OLD, GROWN ON OYSTER SHELL AT FALSEMOUTH BAY, LOUISIANA.

[Figure natural size.]

It is believed that over a large part of the bay the bottom is sufficiently firm to permit the use of light dredges on the planted beds. In water so shallow as that in Falsemouth Bay the dredge, as compared with tongs, is not so economical as in deeper water, but it is believed that it would be cheaper to operate in case of a scarcity of labor.

In Falsemouth Bay, as everywhere else, however, there is a limit to the quantity of good oysters that can be produced, and should the planting industry be established there care should be exercised that neither the density of growth nor the area planted should become excessive. The desire of persons already established to grow as many oysters as possible on a given area, and the equally strong desire of prospective planters to establish themselves in places where others have been successful has more than once brought difficulties to all.

THREE-MILE AND NINE-MILE BAYS.

Three-mile Bay and its contiguous waters constitute the most important oyster region of St. Bernard Parish. Three-mile Bayou is a broad, deep passage connecting Mississippi Sound with the interior of the Louisiana marsh, and the vessels engaged in carrying oysters to the oyster houses and canneries on the mainland lie in the sheltered waters at its inner end to receive the cargoes brought there by the luggers engaged in oystering in the adjacent bays and bayous.

In 1905 a large shucking house was erected on the shores of this bay, with the purpose of avoiding the transportation of the bulky, unshucked oysters to the mainland and the return of the shells for planting on the large area which the operating company had leased for that purpose in the waters adjacent to the establishment. Owing to the difficulty of obtaining employees to work in a locality so remote from settlement, and perhaps to other causes not stated, this establishment was soon abandoned. In addition to the bottom held by this company there are several thousand acres under lease in this vicinity and practically all of the leases issued in St. Bernard Parish are in these or immediately adjacent waters.

It is an interesting observation that these planters have overlooked the advantages of the near-by bottoms in Falsemouth Bay to take up areas which are in almost every respect inferior, this action being dictated by the existence of natural beds in the one region and their absence in the other. The fact has been overlooked that the presence or absence of oysters is in many cases conditioned solely by the presence or absence of clean, firm bodies to which the young may attach. Oyster culture in this region has consisted partly of planting seed

oysters from the natural beds, but largely in the deposit of shells, neither having as yet proved very profitable for reasons which were developed by the result of the Bureau's experiments.

The experimental plantation was located about one-third mile west of Shell Point, practically on the border line between Three-mile and Nine-mile bays, though rather in the latter than in the former. It is about 2½ miles in a straight line from the Falsemouth Bay plantation, though the water route between the two, owing to the interposition of Pirate Point Island, is over 4 miles. South Bayou, a shallow body of water with sluggish currents, opens through the shore line about one-fourth mile distant. Between the plantation and Raccoon Island there is a scattering natural growth of oysters of fairly good shape and quality. The water at the plantation is about 3½ feet deep, gradually shelving to 5 and 6 feet toward the middle of the bay.

Tidal waters enter the bay from Nine-mile and Three-mile bayous, flood tides meeting and ebb tides dividing near the plantation, and as the flow through South Bayou is insignificant the currents in this particular region are sluggish. The conditions in this respect are better in both directions along shore, and in Nine-mile Bay near the entrance to the eastern fork of Nine-mile Bayou and in most of Three-mile Bay proper the water flows with fair velocity.

The salinity of the water during the period of the experiments was approximately the same as in Falsemouth Bay, the specific gravity ranging from 1.0028 to 1.0088, with an average for all observations of 1.0057. The average salinity of the waters of Three-mile Bay proper is somewhat higher, the specific gravity off Shell Point averaging about 1.0076. The average during the oyster season was slightly less. The significance of this comparative freshness of the water in its effect upon the flavor of the oyster and the occurrence of enemies has been mentioned in connection with the description of Falsemouth Bay.

Away from the immediate vicinity of the shore the depth of water in Three-mile and Nine-mile bays is between 4 and 6 feet, with somewhat shoaler spots on some of the dense, natural reefs. The bottom on the plantation is composed of moderately soft mud, which grows softer offshore, though its consistency is such as to permit the successful planting of shells over a considerable area.

The supply of oyster food in Nine-mile and Three-mile bays is comparatively low, on the plantation averaging but about one-half the quantity per unit of water found in Falsemouth Bay. Farther to the eastward, off Shell Point, the quantity is somewhat greater, and to the southward the quantity increases from the mouth of Falsemouth Bay to Treasure Bay, where the waters are approxi-

mately as rich as on the Falsemouth Bay plantation or at Bayou St. Denis, in Jefferson Parish.

The following table exhibits the observed data in respect to the oyster food supply, the specific gravities, and the temperatures of the water at the plantation:

FOOD CONTENT, SPECIFIC GRAVITY, AND TEMPERATURE OF WATER IN THREE-MILE AND NINE-MILE BAYS.

Date.	Specific gravity.	Temperature.	Food organisms per liter of water.	
			Number.	Volume.
1906.		° *F.*		*Cu. mm.*
May 8	1.0054	73.4		
9	1.0065	72.5	11,000	0.290
June 9	1.0082	86.0	3,500	.078
July 17	1.0080	83.0	6,000	.060
1907.				
January 5	1.0088	65.0	2,500	.053
April 12	1.0077	75.0	7,800	.203
May 15	1.0057	75.2	8,250	.307
16	1.0038	68.0	7,000	.282
June 9	1.0028	84.2	4,500	.210
July 7	1.0090	84.2	2,500	.037
December 13	1.0071	55.0	4,500	.238
1908.				
June 5	1.0040	87.0	750	.040
July 12	1.0042	84.0	4,500	.137
1909.				
January 23	1.0083	68.0	11,000	.364
Average	1.0057		5,271	.177

During the investigations of 1898 a few borers were found in Three-mile and Nine-mile bays, but none were observed during the experiments here dealt with, and it is probable that they are never destructive owing to the prevailing low salinity of the water. There were, however, many mussels attached to the oyster clusters, and in some cases they undoubtedly interfered materially with the growth of the oysters and seriously curtailed their food supply.

The site for the experiment was selected partly for the sake of comparison with the work in Falsemouth Bay, and partly because it was located on leased bottom and under the care of a watchman. The plantings were made practically synchronously with those in Falsemouth Bay, and in essentially the same manner excepting that no clam shells were used. The first plant was made on May 8, 1906, and others followed on June 9 and July 16, 1906; April 12, May 15, June 9, and July 7, 1907, and on April 23 and June 6, 1908. In all, 16 plantings were made, of which in 11 cases the shells were spread broadcast, and in 5 cases in heaps of from one-half to 1 bushel each. As in Falsemouth Bay, the quantity of shells varied from 200 to 1,000 bushels per acre.

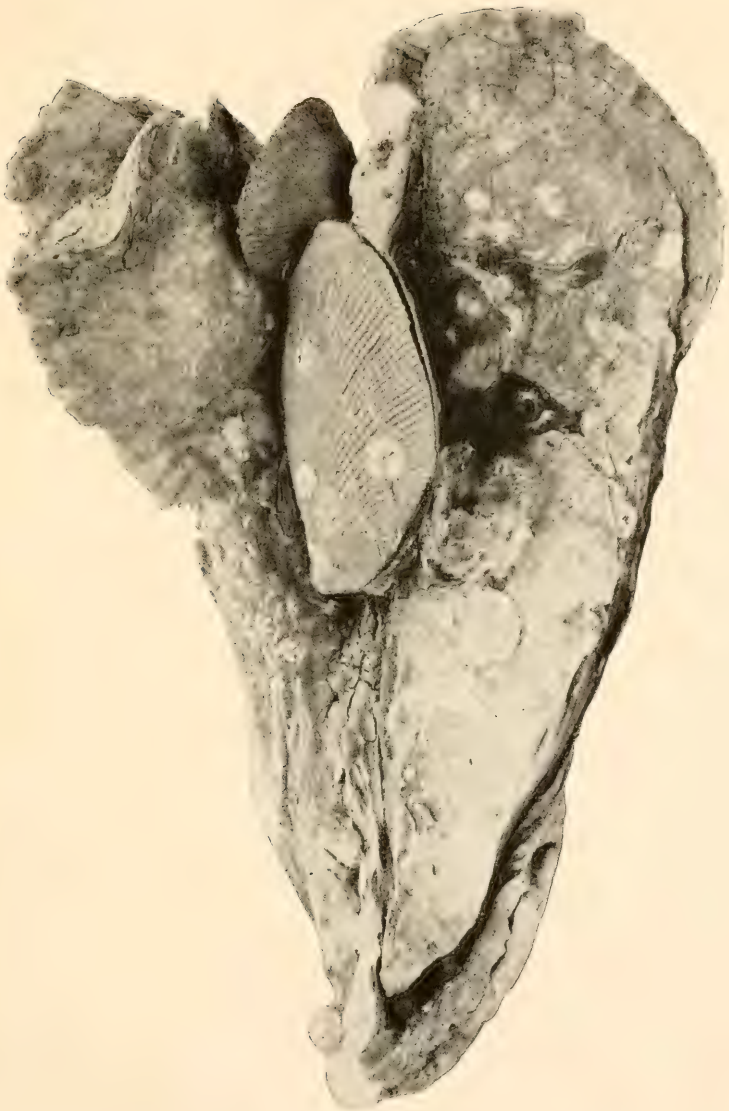
The strike was much heavier than in Falsemouth Bay, a phenomenon correlated with the greater number of breeding oysters in the vicinity and the consequent more general and copious distribution of the free-swimming young oysters. During the first year about 95 per cent of the shells tonged up after the lapse of a few months bore spat, and the average number of young oysters was 6 or 7 to the shell, but after the lapse of the first year the number of oysters per shell had decreased somewhat. In the second year the number of shells receiving a strike was about the same, but there were fewer spat per shell. In the first year the clusters were composed of from 1 to 11 individuals, and in the second year of from 1 to 7 or 8.

Considering the density of the set in these waters the experiments indicate that the shells should not be planted in greater quantities than from 200 to 400 bushels per acre, though on the softer bottoms, where some of the cultch will sink in the mud, the quantity may be increased with advantage to perhaps 500 bushels. On the bottom experimented with there was apparently no advantage in depositing the shells in piles and, in fact, the more evenly they are distributed, the less the chance that the oysters will become so massed as to interfere with their growth and nutrition.

The yield per acre at the end of the thirty-two months was about 1,500 standard bushels of culled oysters, with about an equal amount of shells, fragments, and mussels. The oysters were badly clustered and the débris was made up largely of those which had died from overcrowding. They were long, narrow, thin-shelled, and in general of the type known to the oyster men as "coony" or raccoon oysters.

These oysters were about $2\frac{3}{4}$ inches long at the end of eleven months, $3\frac{1}{2}$ inches in twenty months, and from 4 to 5 inches, with an average of about $4\frac{1}{2}$ inches, at the end of thirty-two months. Although they were longer than those of corresponding age raised in Falsemouth Bay, they were so narrow and flat that the latter were over 50 per cent more bulky in specimens of the same length. The volume of the shells in both cases bore about the same relation to the total volume, and the difference was solely in the deeper and more capacious cavity of the Falsemouth Bay oysters, which is correlated with the volume of the meats.

By actual count the 32-months-old oysters raised on this plantation averaged about 240 to the standard bushel and they turned out about $3\frac{1}{2}$ and 4 pints of drained meats per bushel, approximately half the quantity yielded by a bushel of Falsemouth Bay plants. This extremely low yield for such thin-shelled oysters was due in part to the small size of the cavity, but also largely to their extremely poor condition as regards fatness. The experiment was tried of culling the oysters on half of one section of the planta-



OYSTERS, AVERAGE SIZE, 33 MONTHS OLD, GROWN ON OYSTER SHELLS AT THREE-MILE BAY, LOUISIANA.

[Figure natural size.]

tion one year after the shells were planted and it was found that these oysters, broken in small clusters, improved somewhat in shape and yielded a larger return of meats per bushel, though they were not any fatter than the unculled oysters on the adjoining bottom.

Owing to their shape, clustering, and poor condition, the oysters raised at this place were useless except for steaming. Planted oysters in other parts of the bay were found to be almost as poor in most respects, although perhaps a little fatter. These results are undoubtedly due in part to the crowding of the oysters, and for that reason the breaking up of the clusters at the end of about nine or ten months would be advantageous, but more important factors are the sluggish currents in the places more remote from the discharges into Mississippi Sound and the general paucity of the microscopic life on which the oysters feed.

So far as we have been able to learn the natural oysters in Three-mile Bay and immediately adjacent waters are never more than moderately fat and are often poor as measured by what is attained elsewhere, and it is evident that if oyster culture in this region is to be successful it must be prosecuted with caution. Care must be exercised to locate the planted beds in those places where the currents are strongest, as in the waters near Three-mile Bayou and the eastern fork of Nine-mile Bayou. Oysters and shells should be planted rather sparsely and effort made to prevent the formation of large clusters, or if they are formed they should be broken up as soon as the individuals attain a size and strength of shell to permit culling.

Not only must an excessive density of oyster growth be guarded against but the total area planted should not be allowed to become so great as to overtax the powers of the water to produce food organisms. The authors do not regard this locality as a very promising field for oyster culture, though, undoubtedly, large quantities of oysters of rather poor quality can be produced. It may be that the place will prove valuable for the raising of seed oysters for transport to localities more favorable for fattening.

TERREBONNE PARISH.

Terrebonne Parish includes practically the whole oyster-producing region between Barataria Bay and the mouth of the Atchafalaya River, the product of Lafourche Parish, which adjoins the west side of Jefferson Parish, being insignificant. Several large bodies of water, the western part of Timbalier Bay, Terrebonne Bay, locally known as Cat Island or Wine Island Lake, Lake Pelto, Lake Barre, and Lake Felicity, are included within the limits of the parish, and there are numerous smaller bays, lakes, and bayous which now yield or have yielded oysters. The parish is the westernmost in

which good oysters are produced in considerable quantities, the beds in Iberia and St. Mary parishes furnishing oysters of low grade, few of which are useful for purposes other than steaming. In the oyster season of 1906–7 Terrebonne Parish produced about 190,000 bushels of oysters, and in the following season approximately 300,000 bushels, the increase being due to the beginning of productiveness of several extensive leaseholds.

In 1897, 353,000 bushels of oysters were produced in the parish, practically all of which came from the natural beds. Mr. L. R. Cary [a] states that many of the productive natural beds examined by the senior author in 1898 had been almost obliterated in 1907, and that the greater part of the oysters produced in the parish in the latter year were derived from planted beds.

In 1898 there were in effect in this parish but 32 leases, the aggregate area of which could not, legally, have been in excess of 320 acres, and in reality was probably less. In 1908 there were in force about 430 leases, aggregating about 6,000 acres. Most of these were for parcels of less than 20 acres, but there were several holdings of between 100 and 1,000 acres. The recent tendency has been for the large leaseholders to surrender parts of their bottom, retaining such portions only as experience has indicated to be the most suitable and profitable for oyster culture.

The methods of culture followed usually have not been such as to produce the best grade of oysters. Very few shells are planted and the seed obtained from the natural beds is usually planted without culling, the result being that the oysters grow in large clusters to the serious detriment of their shape and nutrition. If care were exercised to break up the clusters properly into smaller ones or single oysters, the product could be materially improved in shape, quality, and value.

The salinity of the waters of Terrebonne Parish appears to have increased in recent years from the same causes that have operated to raise the density in the upper parts of Barataria Bay, changes in drainage due largely to improvements in the levee system. It is stated that at places in Terrebonne and other bayous where oysters now grow the water was formerly fresh enough for cattle to drink. This is confirmed by a comparison of recent salinity observations with those made in 1898, though the latter were so few that they do not serve as a satisfactory criterion of conditions at that time. The average salinities observed during the present investigations are shown in the following table:

[a] A preliminary study of the conditions of oyster culture in the waters of Terrebonne Parish, La. Bulletin 9, Gulf Biologic Station, Cameron, La.

SALINITY RECORDS FOR WATERS IN TERREBONNE PARISH.

Locality.	1906.	1907.	1908.	1909.
	Sp. gr.	*Sp. gr.*	*Sp. gr.*	*Sp. gr.*
Timbalier Bay	1.0177	1.0156	1.0109	1.0194
Lake Felicity	1.0166	1.0171	.....	.....
Lake Barre	1.0166	1.0164	.....	.....
Seabreeze	1.0164	1.0161	.....	.....
Bay Premiere	1.0202	.....	.....	.....
Lake La Graisse	1.0164	.....	.....	.....
Bay Champiere	.....	1.0146	.....	.....
Terrebonne Bay	1.0172	1.0180	.....	.....
Lake Pelto	1.0180	1.0183	.....	.....
Pelican Lake	1.0172	1.0161	1.0160	1.0192

The localities listed above are all in the region of higher salinities, and in most places it would probably be impossible, or at least impracticable, to raise oysters on cultch, owing to the liability to attack by borers. It is probable that the disappearance of many of the natural reefs is as much due to these conditions as to overfishing, the two agencies together proving disastrous where either alone would be tolerated. In the region west of Pelican Lake, where the saltness of the water is mitigated by the discharge from Atchafalya River, and in Terrebonne, Little Caillou, and other bayous which carry fresh water from the interior, the conditions are apparently such as to permit the set and growth of young oysters on suitable planted material.

Considered as a whole, that part of Terrebonne Parish under observation during the present investigations was about as rich in oyster food as that part of Plaquemines Parish west of the Mississippi River, was considerably poorer than Barataria Bay, and was somewhat less prolific than the region east of the Mississippi in either Plaquemines or St. Bernard parishes. Food organisms were found to be most abundant in Timbalier Bay and Pelican Lake, where the supply was good, and least numerous in the open waters of Terrebonne Bay.

The depth ranges from 3 to 10 feet in the larger bodies of water, but is much deeper in many passes and bayous. There appear to be no very extensive areas of hard bottom in the region observed, excepting on the extinct natural beds, but there are many places where the bottom, while soft, would support deposits of shells or seed oysters, and there is usually a narrow fringe of hard bottom around the shores of the bays.

The experiments in this parish were carried on at two places, Seabreeze and Pelican Lake, but in neither case were satisfactory results attained from the planting of shells. Undoubtedly more favorable places could be found, but the general inaccessibility of the region and the lack of living accommodations operated to restrict the choice of localities.

SEABREEZE.

Seabreeze is the name given to an oyster house, no longer operated, situated on Bayou Terrebonne where it is intersected by Bayou La Graisse and the cut-off to Lake Barre. Below this point Terrebonne Bayou is very shallow and its discharge is mainly through Bayou La Graisse and the cut-off into Terrebonne Bay and Lake Barre, respectively. There are a number of leases located in this vicinity in Terrebonne Bayou, Bayou La Graisse, and Lake Barre, but they are all or nearly all on extinct oyster reefs and are planted with seed oysters obtained from the natural beds. Experiments were undertaken at this place for the purpose of determining whether a method could be devised for using the exceedingly soft bottom common at many places in the parish, and whether the physical and biological conditions were such as to permit the set and development of young oysters on planted materials. The site selected was a small cove on the north side of Bayou La Graisse, where the water has a depth of about 2 feet and the mud is so soft that a man wading will at once sink above his knees, a consistency which any experienced oyster grower would at once pronounce prohibitive. The currents in this cove are sluggish, but a strong circulation is maintained in the adjoining bayou. The salinity of the water at this station is comparatively high, the specific gravity during the two years in which records were made ranging between 1.0138 and 1.0206, few observations departing materially from the general average of 1.0163.

The waters of this vicinity are but moderately productive in oyster food, the observations made in Lake Felicity, Lake Barre, Terrebonne Bayou, and on the experimental beds yielding approximately the same average results. The following table gives the record on the experimental beds:

FOOD CONTENT, SPECIFIC GRAVITY, AND TEMPERATURE OF WATER ON EXPERIMENTAL OYSTER BEDS AT SEABREEZE.

Date.	Specific gravity.	Temperature.	Food organisms per liter of water.	
			Number.	Volume.
1906.		°F.		*Cu. mm.*
April 30	1.0174	78.8	13,500	0.297
May 2	1.0158	80.6	9,000	.193
30	1.0171	83.3	8,000	.286
31	1.0165	86	.....	.....
June 1	1.0162	83.3	6,000	.190
July 5	1.0164	78.8	1,000	.016
7	1.0184	78.8	2,000	.152
1907.				
January 16	1.0205	72	5,400	.144
April 20	1.0158	66.5	1,800	.097
June 29	1.0146	87	2,500	.149
Average	1.0163	.....	5,355	.169

No actual observations of oyster enemies were made at this station, but the conditions are such as to make it probable that the borer may occur in sufficient numbers to prevent the successful application of the methods of planting shells and other materials for the purpose of securing a strike of spat. At this station no brood oysters were planted, the supply of floating fry originating on the natural and planted beds in contiguous waters being amply sufficient to fill all requirements. In all 16 plantings were made, the methods being more varied than at any other station. The first cultch was planted about the end of April, 1906, and additional sections of the bottom were planted on the last of May and early in July of the same year. The results were such as to discourage further work, and after a final examination of the beds in April, 1907, the experiment was abandoned.

Oyster shells were deposited both broadcast and in small piles in proportions varying from 400 to 600 bushels to the acre, and after the lapse of about one month were found to be so densely covered with spat as to defy count, in many cases the small oysters being superimposed in several layers. At the end of two months many of the shells spread broadcast had become engulfed in the mud, but those still unburied bore large numbers of young oysters measuring between three-fourths and 1½ inches in length, with many smaller ones. The shells deposited in piles were still unburied in larger proportions, and all not covered by the mud, whether they were on the surface of the piles or in the interior, bore an average of about 35 young oysters, each ranging from one-half inch to over 1½ inches long. In April, 1907, practically all of these shells, both those spread broadcast and those planted in piles, were buried in the mud. Only 4 or 5 shells, of those planted in piles, were recovered, and these bore 7 oysters, the largest of which was 2¾ inches long.

Other shells were planted on a flooring of palmetto leaves, on the supposition that the fibrous matter of the latter would resist decay and serve as a mattress to prevent the sinking of the shells. Though this experiment was by no means a success the results were the best attained in this locality, and after the lapse of a year a few oysters measuring 1¼ to 3¾ inches long were recovered from the bed. It is possible that in the remote future, when it may be advisable to utilize the very soft bottoms of Terrebonne Parish, some modification of this method may be of value, but it has no present utility. Several plantings were made of palmetto leaves and brush thrust by their stems into the mud. It was hoped that these materials would hold together long enough to yield marketable oysters and that the vegetable fragments and oysters falling to the bottom would eventually stiffen the consistency of the surface mud and make a firm foundation for future operations. The strike on these materials, especially on

the palmetto, was enormous in quantity. At the end of the first month there were over 800 oysters between one-eighth and one-half inch long on each leaf and there were probably over three times that many smaller spat. One month later, however, practically all of these had dropped off and had become lost in the mud, while the few still attached fell away at the slightest touch. After the lapse of a year no trace of oysters was to be found, the brush had become covered with slime and more or less rotten, while the palmetto was reduced to a few wisps of fiber still attached to the stem and a small mass of decayed material on the bottom.

The foregoing experiments exhausted the list of cultch materials available at this place, and in view of the results the work was abandoned. It is believed that the hopelessness of the attempt to use at present the very soft bottoms in this vicinity has been demonstrated. They undoubtedly can be made available for oyster culture by the use of large quantities of sand or shells to form an artificial firm surface, but such materials would have to be transported long distances and the expense would be at present prohibitive, especially in view of the area of naturally more favorable bottom to be found in adjacent waters. That a prolific strike occurs in this region was shown and it is probable that it can be depended on yearly. It was also demonstrated, by the few surviving oysters, that the conditions are favorable for very rapid growth.

PELICAN LAKE.

After the abandonment of the plantation at Seabreeze, experiments were begun at Pelican Lake, on the recommendation of the state oyster commission. Large operations in planting seed oysters from the natural beds had recently been undertaken by a company at Houma, and it appeared desirable to determine whether the method of cultch planting to catch a strike of young oysters was feasible. The location also appeared to have some advantage from the presence of a watchman to prevent depredations and the destruction of the boundary marks, but the expectations in this respect were not realized.

Pelican Lake is a somewhat quadrangular body of water lying northwest of Lake Pelto, with which it communicates through Bay Rond and connecting bayous. At its southwestern corner it is connected with Wilson Bay and on its northern and northeastern borders are the mouths of several considerable bayous. The bay has an area of 5 or 6 square miles and a depth, toward the middle, of about 6 or 7 feet, gradually shoaling to 3 or 4 feet closer to the shores. There are strong currents near the entrances of Wilson Bay and Bayou Go-to-Hell, but in the greater part of the lake they are sluggish.

The salinity of the water is rather high, the specific gravity ranging, during the three years in which it was under observation, between 1.0136 and 1.0209, the average of all observations, 34 in number,

being 1.0167. The salinity is least in spring and summer and greatest in December and January. The bottom of the greater part of the lake is composed of soft mud, but there is a fringe of moderately hard bottom extending around most of the rim for a distance of several hundred yards from the shore. Near the entrance to Wilson Bay and at several other places in the southern part of Pelican Lake there are hard areas of limited extent occupying, apparently, the sites of extinct oyster beds. Oyster planting is at present confined to the littoral fringe of moderately hard bottom, and although the soft bottoms of the center of the lake eventually may be utilized, their preparation would involve an expense so considerable as to prevent their occupation until the naturally more suitable bottoms are more fully occupied.

In oyster food Pelican Lake is richer than any waters between there and Barataria Bay, with the single exception of Timbalier Bay, with which it is about on a parity. In this respect, however, it is inferior to the sites of the experimental plants at Falsemouth Bay, Bay Tambour, and Bayou St. Denis, but is superior to Three-mile Bay and Seabreeze. The most prolific waters are in the northern part of the lake, where the influence of the strong currents in Bayou Go-to-Hell is experienced, the region close to Wilson Pass, also a locality with strong currents, being fair. The fluctuations in the food supply, the specific gravities, and the temperatures of the water, observed at various times during the course of the investigations, are shown in the following table. In most cases the data recorded are the averages of several observations made practically simultaneously in different parts of the lake.

FOOD CONTENT, SPECIFIC GRAVITY, AND TEMPERATURE OF WATER AT PELICAN LAKE.

Date.	Specific gravity.	Temperature.	Food organisms per liter of water.	
			Number.	Volume.
1906.		°F.		*Cu. mm.*
June 6	1.0180	83.5	10,900	0.119
July 8	1.0154		4,125	.077
August 20	1.0204	84	9,000	.128
November 7	1.0205	70.7	12,875	.302
1907.				
January 17	1.0209	73	1,800	.082
April 20	1.0180	68	3,600	.193
May 9	1.0170	77.9	10,250	.409
10	1.0156	73.4	8,500	.312
29	1.0150	77	7,325	.313
June 30	1.0168	86.6	2,850	.077
July 23	1.0145	87.3	2,650	.135
December 7	1.0169	58	19,500	.943
1908.				
April 15	1.0154	79.5	36,000	.561
June 16	1.0171	83	5,000	.235
Average	1.0172		9,598	.277

The drumfish is reputed to cause some damage in these waters and it is said that 5 per cent of the seed oysters planted are killed by it. There were formerly several natural oyster beds, but they are now wholly extinct, and it is stated that they have been unproductive for about twenty years. It is believed that the extinction of these beds is due largely to the great numbers of borers found in the lake. During the progress of the experiments hereafter recounted practically all of the young oysters were killed by these industrious enemies, and it may be fairly assumed that the same conditions obtained on the original natural beds. With the majority of the spat being killed in this manner and the adults being taken by the oystermen, the utter extermination of the beds was practically inevitable. It is possible, also, that the water has increased in salinity, and, therefore, has become more favorable to the borers, through the improvement of the levee system and the consequent changes in drainage. We have no evidence that this is the case in the region under discussion, but it is undoubtedly true in certain localities to the eastward already mentioned. The experiments in Pelican Lake were conducted on five sites, three in the northern part of the bay and two in the southern half. The characteristics of the several localities planted are as follows:

Bed A.—North of the mouth of California Pass. Bottom soft. Currents moderately strong.

Bed B.—West of the mouth of Bayou Go-to-Hell. Bottom moderately hard. Currents strong.

Bed C.—On the west side of the lake about halfway between the preceding and Wilson Pass. Bottom moderately hard. Currents not noted.

Bed D.—East of the mouth of Wilson Pass. Bottom hard, on edge of extinct reef. Currents of moderate strength.

Bed E.—South of the mouth of California Pass. Bottom soft. Currents moderate.

On all of these the mud, as shown by mechanical tests with the mud-sounding machine, was sufficiently firm to warrant planting without previous preparation of the bottom.

Planting of oyster shells spread broadcast were made on each of these beds in May and June, 1907, and, in addition, on bed E in April, 1908, in quantities varying from 600 to 900 bushels per acre. No experiments were made in planting seed oysters, as that method was already under trial on a large commercial scale.

On May 9, 1907, a single planting was made on bed B, and on June 30 every shell was found to bear spat about one-half inch long, while on the same date sections of this bed and bed A, planted on May 27 and 29, had spat on from 25 to 45 per cent of the shells. Sections on beds C and D, in the southern part of the lake, planted on the same

dates, were practically devoid of living spat, although there were a few dead ones bearing evidence of having been killed by borers.

In April, 1908, when the beds were examined all sections of bed A were devoid of young oysters. On bed B every shell tonged bore numerous spat killed by borers, but there were among them a few young live oysters from 1 to 1½ inches long. Bed D was entirely exterminated so far as living oysters were concerned, and the shells were much corroded by the yellow boring sponge, which produces the condition which the oystermen term "worm-eaten."

On the section of bed E planted June 30, 1907, about 40 per cent of the shells bore, each, one or two oysters about 1 to 2 inches long in the following year, but an adjoining section planted in April, 1908, had a heavy set of spat entirely killed by borers when examined in June.

On the seed oysters which had been planted in this lake there are a very small growth of spat, much boring sponge, and many borers. This seed was obtained largely from Pointe au Fer Reef at the mouth of the Atchafalaya River; it was very rough and mixed with débris, and no effort appears to have been made to cull it or even to break up the larger bunches. In consequence the oysters now on the beds are badly clustered and crowded, to the detriment of both shape and condition. When last examined in January, 1909, they were of large size, averaging, as taken from the beds, about 150 per bushel, and they were plump but watery in appearance.

It is probable that Pelican Lake would prove an excellent place for growing oysters if clean, properly culled seed were used, and if it were not planted too densely. The margin only of the lake is fit to use in its unimproved condition, but the soft mud in the middle should serve as a good nursery for oyster food, the supply of which, in the lake at large, is good. On the other hand, as shown by the experiments just recounted, it would be futile to attempt to raise oysters from spat caught on planted shells or other cultch, owing to the favorable environment which the high salinity of the water furnishes to the borer. It is probable that the numbers of this destructive pest have been greatly augmented by the accessions to those naturally present brought in with the rough seed from the natural reefs, although, both from its location and its repute, it is not believed that Pointe au Fer is especially pernicious in this respect.

OYSTER FOOD.

In certain parts of the Louisiana coast oystermen and planters have encountered the difficulty frequent in all oyster-producing waters, the constant or occasional failure of the oysters to fatten. In Three-mile Bay and some of the adjacent waters, in Bay Adam and vicinity,

and at various places in Terrebonne Parish, this difficulty has become a serious impediment to oyster culture.

In some cases the trouble is undoubtedly due to the overcrowding of oysters on the planted beds or to the planting of such extensive areas that the total oyster population of the region affected is in excess of the number for which the waters are able to furnish an ample food supply. In any given body of water, under fixed conditions of drainage and tidal flow, there is probably a more or less fixed limit to the production of the minute plants on which oysters feed, and a correlated limit to the number of oysters that can be produced for the market. Where this limit is exceeded either by planting densely over a small area or more sparsely over an extensive one, especially in an inclosed body of water, the result is manifested in the poor condition of the product. This is not a theory, but a demonstrated fact, analogous to overgrazing of cattle on pasture lands, and must be given consideration by the successful oyster culturist. The same condition is induced by a heavy growth of mussels and other organisms whose food is the same as the oysters.

There are, however, other cases of failure of oysters to fatten which are not so well understood. Regions formerly favorable sometimes entirely cease to produce marketable oysters, even where there has occurred no material change in the density and distribution of the oyster population. In such instances it often happens that there has been some coincident sudden or gradual change in the drainage or in the tidal flows.

Something of this nature seems to have occurred in the vicinity of Bay Adam, where practically no fat oysters are now produced, though we were informed that in former years good oysters were grown regularly. Coincidently with this change in conditions, the rice fields draining into the bay went out of production. It is the opinion of some of the oyster planters that the two occurrences were causally related, and the authors concur as to the probable truth of this explanation. Undoubtedly the drainage from the rice fields carried with it considerable quantities of the fertilizing salts required for the production of the microscopic plant food of the oyster, and since these enriching materials have been largely or entirely cut off the waters have become less fertile and productive. It has been proposed to correct this deficiency in several places by conducting fresh water to the oyster grounds from the Mississippi River through siphons such as were used in the irrigation of the rice fields. Whether or not this measure would afford effective relief is a matter of some doubt. It can hardly be questioned that much of the fertility of the waters formerly came from the organic and mineral matter carried from the rice fields themselves, and it is doubtful whether the river water itself carries organic matter in sufficient quantity to afford material

relief, heavily charged though it may be with suspended mineral particles and salts in solution.

More common phenomena of the oyster beds are the seasonal and irregularly periodical fluctuations in the condition of the oysters. In some years the oysters in certain regions may be fat and in other places poor, while at another time the conditions will be wholly reversed. Again seasons will occur when the oysters are poor almost everywhere without apparent reasons. That these fluctuations are immediately due to the relative abundance or scarcity of available food admits of but little doubt, but granting that the assumption be true the difficulty instead of being solved is merely shifted to a more remote cause. Is there an actual deficiency in the quantity of food organisms and if so, what are the chemical, physical, and biological causes producing it? Or is there an abundance of food merely unavailable on account of some peculiarity of its distribution?

The feeding of oysters has been studied for many years, both in this country and in Europe, but we still know very little concerning the subject, other than the mere nature of the food and the general anatomical means by which it is ingested. It is only within three years that it has been possible even approximately to estimate the comparative volumes of the food carried by the waters of different localities, and such data are available for but a few places, all previous results being too indefinite to be of any material value. Even with the methods at present employed the results are not justly comparable between various localities unless large numbers of observations are made embracing all average weather conditions; though in the case of neighboring localities, where the weather conditions may be assumed to be approximately the same, simultaneous or approximately simultaneous observations may be accepted as comparable.

It may be observed in the preceding tables, presented in the discussion of the experiments in oyster culture, that there is wide divergence in the number and volume of the food organisms present in the water at different times. In Pelican Lake, for instance, the number of diatoms and other food organisms varied between 1,800 and 36,000, while their volume ranged between 0.077 and 0.943 cubic millimeter per liter of water (a cubic millimeter is about equal to the volume of a cube measuring one twenty-fifth of an inch in diameter, and a liter is about $1\frac{1}{8}$ quarts). This divergence is due very largely to the varying state of the weather, the smaller results being as a rule obtained after and during periods of calm, while the higher ones were invariably observed at times when strong winds prevailed. The reason for this is readily understood. The water specimens for the determination of the food content are taken from the stratum lying between 2 and 12 inches of the bottom. Many of the or-

ganisms, especially the minute plants known as "diatoms," on which the oyster feeds, live habitually on or close to the bottom, from which they are lifted and transported mainly through the agency of waves and currents. Many of them possess feeble powers of locomotion, but these are practically negligible in most of the bottom-dwelling species. It is therefore obvious that when the water is agitated by heavy winds and the bottom is stirred, the food organisms which in calm weather lie more or less quiescent on the mud will become mingled with other sedimentary matter in suspension in the water and the quantity taken in the specimen will be vastly augmented. This accords with field observation and is confirmed by the correlation existing between the volume of the food and that of the sand and other sedimentary matter in the precipitate from the water specimens. When the food is much in excess of the average, ordinary sediment is likewise large in volume, and when it is at the minimum, inorganic matter is comparatively lacking.

At present there appears to be no accurate method by which these fluctuations in the sedimentary condition of the water may be taken into account in the study of the comparative values of different localities for purposes of oyster culture, the most that can be done being to indicate more or less indefinitely the general state of the weather at and immediately preceding the time at which the observations are made. If observations could be taken at each locality daily or at frequent intervals throughout the year, the average results attained in different places would be strictly comparable, for the methods employed show the quantity of food which is actually available to the oysters at the time of observation.

When the diatoms and other food organisms are lifted from the bottom through the mechanical effect of the waves it is almost certain that the oysters should profit. Therefore, although we have as yet no experimental data which would render the statement positive, it is extremely probable that the matter of wave action must be added to the numerous other factors entering into the food supply of oysters, and that a certain amount of agitation of the bottom favors fattening. A region subject to this phenomenon should accordingly be preferable to one not so subject, and a season of strong winds should be more favorable than one of prevailing calms or breezes so light as to leave the bottom wholly undisturbed. When we have accumulated more data on the subject it is not improbable that in some cases seasons in which oysters fail to fatten may be found to be characterized by the prevalence of light winds.

During the course of the experiments in oyster culture previously described an attempt was made to study the distribution of oyster food on the coast of Louisiana in the hope that facts could be garnered which would throw some light on the reasons for local and

seasonal differences in its quantity. It may be confessed at once that the results lead to no satisfactory conclusions, owing to the necessarily limited number of observations in most places and the accidental fluctuations introduced by the factor just discussed, though the data gathered will probably assist to a solution of the problem when considered in relation to experimental work now being carried on at other places. The accumulation of data is probably the most that can be attempted for several years to come.

During a period of thirty-three months 498 food determinations were made at 61 different stations. At most places observations were made but once or twice in each year, but at the experimental plants they were made more frequently. In the case of the latter there is perhaps some basis for comparison, but in most other places the number of observations was too small to be assumed to represent anything approaching average conditions. The following table shows the average quantity of food and the salinity of the water at all places in which five or more observations were made:

AVERAGE QUANTITY OF OYSTER FOOD IN VARIOUS LOUISIANA LOCALITIES, BASED ON FIVE OR MORE DETERMINATIONS.

Locality.	Number of observations.	Average specific gravity of water.	Food organisms per liter of water.	
			Number.	Volume.
				Cu. mm.
Three-mile Bay	14	1.0064	5,675	0.177
Falsemouth Bay	13	1.0056	9,000	.342
Nine-mile Bay, south end	8	1.0076	7,200	.217
Treasure Bay	7	1.0102	6,630	.169
Big Mussel Bay	7	1.0119	7,000	.185
Saw Bay	7	1.0162	5,230	.192
Blind Bay	6	1.0174	4,270	.172
Caligo Bay	8	1.0181	10,160	.252
Black Bay	7	1.0160	7,900	.237
Long Bay	6	1.0160	6,725	.219
Cock Bay	8	1.0176	6,350	.166
American Bay	7	1.0184	6,900	.248
California Bay	7	1.0195	5,540	.189
Quarantine Bay	7	1.0190	8,640	.329
Bastien Bay	9	1.0117	4,890	.155
Bayou Cook	5	1.0112	7,060	.222
Bay Adam	26	1.0115	6,000	.120
Grand Bayou	11	1.0123	4,275	.126
Bay Sans-bois	9	1.0095	12,522	.320
Bay Baptiste	10	1.0107	7,525	.230
Bayou St. Denis	19	1.0090	10,460	.337
Barataria Bay (Quartelle)	11	1.0151	17,363	.580
Bayou Bruleau	10	1.0120	9,675	.241
Bayou Rigault	19	1.0157	9,250	.235
Grand Isle	48	1.0127	5,690	.195
Bay Tambour	19	1.0147	10,200	.295
Lake Raccoisi	9	1.0148	17,500	.211
Timbalier Bay	7	1.0160	7,000	.264
Lake Felicity	5	1.0169	6,600	.193
Seabreeze Factory	18	1.0164	5,675	.169
Lake Pelto	5	1.0182	5,600	.188
Pelican Lake	38	1.0167	12,600	.252

As the salinity depends upon the relative proportions of the admixture of fresh and salt waters, the specific gravity may be taken as an index of the degree to which a locality is influenced by the

discharge of fresh water from the land. A low specific gravity, such as obtains in Three-mile Bay and vicinity, indicates a close relation to land drainage, as compared with another locality, such as Caligo Bay, in which the specific gravity is high. If land drainage and its contained fertilizing salts are highly important, as we generally suppose, in stimulating the growth of oyster food, it would be expected, other things being equal, that a low specific gravity would be correlated with a high food content as compared with a high specific gravity in the same system of waters. An examination of the foregoing table exhibits no such relation between the salinities and the food contents of the waters, when the various connected waters are compared with others in the same system or chain. The authors have prepared tables showing the specific gravity and food content of the waters at various times in each of the localities enumerated in the foregoing table of averages, and these show the same apparent lack of correlation, a high food content occurring sometimes with a low and at other times with a high specific gravity in the same locality.

It is probable that these results are to be regarded as nonconclusive rather than as showing that a relationship does not exist. The uncontrolled factors, particularly the stirring up of the bottom by wave action, are too important to be disregarded and their influence can be overcome only, apparently, by making many more observations than were possible under the conditions of the present investigation. Deductions from work of this character, unless the observations can be carried on systematically almost daily throughout the year, are likely to be misleading, and the investigations of the oyster food of Louisiana waters can be regarded as shedding no light on the effects of introducing river water in such localities as Bay Adam with the purpose of improving the conditions for fattening oysters.

SUMMARY AND CONCLUSION.

The following epitomizes the results of the experiments and investigations of the oyster regions of Louisiana, east of the Atchafalaya River, between April, 1906, and January, 1909, and the deductions which the authors draw from their observations:

1. It is believed that the future of both the natural beds and oyster culture in Louisiana will be benefited by greater restrictions on the issuance of permits to take unculled oysters from the natural beds. A too general practice in this respect tends to the depletion of the natural beds of not only oysters, but the shells that are essential for their future prosperity, and at the same time has the effect of discouraging the planting of shells on leased bottoms.

2. A limited issuance of such permits to take unculled stock from designated beds which are known to be overcrowded or which are

subject to disaster from freshets would prove of benefit to the beds designated and to oyster culture in general. It would result in saving many thousand barrels of oysters which would otherwise die from the effects of fresh water and crowding or which would never reach a good marketable condition owing to starvation and suffocation from an overpopulation of the reefs.

3. Beds known to produce few or no marketable oysters on account of overcrowding should be temporarily set apart as seed beds, from which the planters may secure culled oysters for bedding purposes under the provisions of the present law permitting such oysters to be taken after the close of the regular season. The provision of the law permitting this practice in the waters east of the western boundary of Plaquemines Parish could be advantageously extended, under the restriction just stated, to other parts of the state.

4. It will prove of great advantage in the future and will avoid ultimate embarrassment and expense to both the state and the lessees of oyster bottom if some measure can be adopted to insure the reference of leasehold corners to permanent landmarks in such manner that disputed boundaries can be accurately redetermined. This suggestion may appear to be of but little present importance, but the experience of other states shows that ultimately it must be followed.

5. The results of the foregoing investigations, and observations made during their course, indicate that as a potential oyster-producing state Louisiana is not excelled, if equalled, by any other section of the country. Wherever experiments were conducted it was shown that there was an abundant strike of spat, and the indications are that this can be depended upon to occur yearly without fail, though in some cases it is often destroyed by the borer. This danger, however, is not to be feared in any place where the specific gravity of the water is less than 1.012—that is, where there is an admixture of about equal parts of salt and fresh water—and the seed-producing area of the state is therefore ample to support an immense planting industry. The Louisiana planter has consequently little to fear from the bugbear of his northern confrere, the occasional or frequent scarcity of seed.

6. The depth of water over most of the oyster-producing area of the state is so small as to minimize the cost of taking up the oysters, and the comparatively sheltered situation of much of the bottom suitable for oyster culture, and the mildness of the weather as compared with that encountered in more northern localities during the oyster season, allow the work to be prosecuted with less frequent interruptions and therefore more economically. The warmer temperature in spring and fall, however, tends somewhat to reduce the length of the season.

7. The configuration of the Louisiana coast, with its broad frontage of salt marshes, which will probably always preclude its occupation by a considerable population, renders the oyster grounds practically immune from dangerous sewage pollution, a consideration of vital importance to the consumer and of corresponding advantage to the producer of oysters.

8. The greater distance of the Louisiana coast from most of the larger centers of population is its chief disadvantage as compared with the oyster regions of the Middle Atlantic States. In respect to the growing population of the West, however, it labors under no such impediment to development, as is shown by the vast increase in the quantity of Louisiana oysters marketed since the enactment of the laws now in force.

9. The oyster food supply in the waters of Louisiana is generally good and the growth of oysters is rapid. As shown by the experiments previously described, good marketable oysters can be produced within two years of the time at which they attach to cultch, and a corresponding growth occurs in seed oysters. The oyster planter therefore reaps a quicker and larger return on his investment than he would in places where the growth is slower.

10. The results of the experiments show that a larger quantity of oysters can be grown per acre than can be produced in most places. On the small experimental beds at Falsemouth Bay, Three-mile Bay, and Bayou St. Denis there were, at least, upward of 1,000 standard bushels per acre at the end of two years from the time of planting the cultch, and it is understood that this quantity per acre is grown on planted beds in other parts of the state.

11. The area of bottom available for oyster culture is large, but it varies in the character of the oysters produced and consequently in the purposes for which they can be used. It is probable that in practically all places where the fresh water exceeds the salt water and the latter does not fall much below 20 per cent in the admixture, seed oysters can be raised on suitable bottom, either for transplanting to places more favorable for growth or for the production of market oysters in situ. Three-mile Bay and vicinity appears to be of the first sort and Falsemouth Bay and Bayou St. Denis fall in the second category. In places in which the salinity is higher than that described above, the salt water in the mixture being in excess of the fresh, seed oysters usually can not be produced in considerable quantities, not on account of the absence of a strike but because most of the spat is destroyed by drills. Such localities, of which Bay Tambour is a type, may often be excellent for producing market oysters from seed raised elsewhere.

12. The experiments at Three-mile Bay demonstrated the possibility of producing a heavy growth of oysters on planted shells, but

the strike was so prolific that they were badly clustered, of bad shape and so poor in quality that they were of small value for market purposes. Oysters planted commercially in contiguous waters were of the same character. To be of much value this growth would require culling, the breaking up of the clusters and replanting less densely, preferably on harder bottom than most of that in the vicinity, and where the currents are stronger and food more abundant. It is not certain that this would be commercially profitable under present conditions. The oysters at present raised in this vicinity are suitable for canning purposes only.

13. In Falsemouth Bay a good strike occurred throughout the spring and summer in the three consecutive years of the experiments. The oysters produced exhibited a rapid growth, were in small clusters, and produced 7 pints of perfectly drained meats per standard bushel, an equivalent of over a gallon as measured at the shucking houses. They were nearly all extra selects, and the locality appears to the authors to be especially valuable for the production of oysters for the raw trade. There is a large area of hard bottom in the bay, and while the quality of the oysters would probably deteriorate if it were all planted, a considerable proportion, especially near the openings of the bayous discharging into Mississippi Sound, could be planted with confidence of good results. The only drawback to the oysters raised on the experimental beds was that the shells were rather brittle and sometimes broke in shucking.

14. At Bayou St. Denis, in Barataria Bay, the oysters raised on the experimental beds from planted shells were as fine as any that are grown on the Atlantic coast. They grew rapidly, had round, deeply cupped, rather heavy shells, and were very fat. Owing to the thicker shells they produced proportionately less meat than the preceding, but "turned out" about 5½ pints, thoroughly drained, per bushel, an equivalent of about 7 pints shucking-house measurement. They were equal in quality to the famous "Lynnhaven Bays" of Virginia, which sell for $3 or more per bushel in the northern markets, and they can be produced in much larger quantity per acre. They are readily salable in the shell as barrel stock.

15. At Bay Tambour, on the contrary, while there is a good set, the young oysters are soon killed by the snail or borer. Seed oysters 2 inches or possibly not less than 1½ inches long appear to be immune. The seed oysters planted at this place grew rapidly and attained a condition little if any inferior to those at Bayou St. Denis. A considerable area of the southern part of Barataria Bay and the contiguous waters has similar characteristics and a number of leases have been taken in that vicinity since the beginning of the experiments. Nearly 100,000 standard bushels of excellent oysters were produced on planted beds in Barataria Bay as a whole in the season

1908–9, though previous to these experiments the region was totally unproductive.

16. At Seabreeze the attempt to discover a means of using excessively soft bottom was unsuccessful. It was demonstrated that a heavy strike occurs, but the salinity of the water is so high that it is probable that trouble with the borer would be encountered. The growth of oysters is rapid and seed planted on hard bottom in the vicinity should flourish.

17. At Pelican Lake a heavy strike occurs, but the spat are soon killed by borers. The region is fairly suitable for growing market oysters from seed, but the latter should be culled at least sufficiently to break up the larger clusters, and the seed should not be planted so densely as to be crowded when it has grown to marketable size.

18. The oyster-food investigations carried on coincidently with the experimental work were inconclusive in demonstrating a relationship between the quantity of surface drainage water on the beds and the production of food organisms. They showed, however, that the latter are abundant in Louisiana as compared with most oyster regions.

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